ENGINEER'S ADDENDUM NO. 01
TO THE BID DOCUMENTS (PLANS AND SPECIFICATIONS) FOR
Beaver Creek Clean River Project Phase IV – Third Avenue Tunnel
AWB Contract # 4-G

City of Albany
Albany County, New York
October 13, 2020

The following changes and/or additions shall be made to the plans and/or specifications. All other requirements of the contract documents shall remain the same. Acknowledge receipt of this addendum by inserting its number and date in the Bid Proposal.

Changes/Additions to the Bid Documents:

THIS ADDENDUM is hereby made a part of the contract documents on the subject work as though originally included therein. The following amendments, additions and/or corrections shall govern this work.

This Addendum is in the following parts as follows:

Part I	- Pertaining to Drawings
Part II	- Pertaining to Technical Specifications
Part III	- Clarifications/responses to Contractor Questions
Part IV	- List of Attachments

PART I - PERTAINING TO DRAWINGS

C-101 – 30-IN DIVERSION PIPE PLAN & PROFILE SHEET 1 OF 2

1. PLAN
   a. At Structure #2, call-out for the temporary working shaft updated to read "14'x25'L JACKING/RECEIVING SHAFT".
   b. At Structure #3, call-out for the temporary working shaft updated to read "25' DIAMETER JACKING/RECEIVING SHAFT".
   c. WORKING POINT (WP) TABLE format updated. Content NOT modified.

2. NOTES
   a. Added Note 9. It reads "JACKING/RECEIVING SHAFT/PIT SIZES SHOWN ARE MAXIMUM PERMITTED. CONTRACTOR SHALL BE RESPONSIBLE FOR SHAFT/PIT SIZE, LAYOUT OREIENTATION, DEPTH, ETC."
   b. Added Note 10. It reads "CONTRACTOR SHALL COORDINATE WITH PHASE V CONTRACTOR WHEN TUNNELIGN BETWEEN STRUCTURE #2 AND STATION 0+00. CONSTRUCTION AND POSITIONING OF RECEVING PIT AT STATION 0+00 MAY BE IMPACTED BY PHASE V ACTIVITIES."

3. PROFILE
   a. Callout to casing deleted.

b. Casing lines deleted from each segment between STA. 0+00 and 14+25 (3 full segments plus 1 partial segment, as shown on C-101).
c. At Structure #2, call-out for the temporary working shaft updated to read "14'x25'L JACKING/RECEIVING SHAFT".
d. At Structure #3, call-out for the temporary working shaft updated to read "25' DIAMETER JACKING/RECEIVING SHAFT".

C-102 – 30-IN DIVERSION PIPE PLAN & PROFILE SHEET 2 OF 2

1. PLAN
    a. At Structure #5, call-out for the temporary working shaft updated to read "15' DIAMETER RECEIVING SHAFT".
    b. At Structure #6, call-out for the temporary working shaft updated to read "14'x25'L JACKING SHAFT".
    c. WORKING POINT (WP) TABLE format updated. Content NOT modified.

2. NOTES
    a. Added Note 10. It reads "JACKING/RECEIVING SHAFT/PIT SIZES SHOWN ARE MAXIMUM PERMITTED. CONTRACTOR SHALL BE RESPONSIBLE FOR SHAFT/PIT SIZE, LAYOUT OREIENTATION, DEPTH, ETC."

3. PROFILE
    a. Two (2) instances of callout to casing deleted.
    b. Casing lines deleted from each segment between STA. 14+25 and 23+25 (1 full segment plus 1 partial segment, as shown on C-102).
    c. At Structure #5, call-out for the temporary working shaft updated to read "15' DIAMETER RECEIVING SHAFT".
    d. At Structure #6, call-out for the temporary working shaft updated to read "14'x25'L JACKING SHAFT".

C-601 – SITE DETAILS

1. DETAIL 7, to leader reading "OPTIONAL EXTRA EXCAVATION BEDDING AS ORDERED BY ENGINEER", added "SEE NOTE 3".
2. DETAIL 7, added Note 3 "TRENCH STABILIZATION REQUIRED FOR UNSUITABLE SUBGRADE (WET, SOFT, UNSTABLE SOILS) SHALL INCLUDE OVEREXCAVATION AND BACKFILL. MATERIAL SHALL BE CRUSHED ROCK ½" – 2 ½" WRAPPED IN NON-WOVEN 10-OZ. GEOTEXILE FABRIC. GRAVEL SHALL BE COMPATED TO 75% RELATIVE DENSITY AND MEET ASTM D4235 REQUIREMENTS.

C-604 – DIVERSION PIPE, CASING AND INSTRUMENTATION DETAILS

3. DETAIL A updated in entirety.

D-700 – WORKING SHAFT SUPPORT OF EXCAVATION DESIGN REQUIREMENTS

1. DETAIL A, MAXIMUM PRESSURE BELOW BOTTOM OF EXCAVATION
    a. Passive pressure nomenclature typographical error corrected for the variable Kp. It now read $Kp^{0.5}$ instead of $KP^{0.5}$.
    b. Leader pointing position adjusted for the note "EXISTING GROUND SURFACE (EL. VARIES)"

2. GENERAL NOTES
    a. Added Note 6. It reads "CONTRACTOR SHALL USE THE DESIGN PARAMETERS

SPECIFIED, OR VALUES INTERPRETED BY CONTRACTOR’S ENGINEER, WHICHEVER IS MORE CONSERVATIVE, TO DEVELOP THE DRIVING AND RESISTING PRESSURES.”

b. Added Note 7. It reads “CONTRACTOR SHALL REFER TO THE GEOTECHNICAL BASELINE REPORT AND THE GEOTECHNICAL DATA REPORT FOR SUBSURFACE STRATA INFORMATION.”

PART II - PERTAINING TO TECHNICAL SPECIFICATIONS

Table of Contents:

1. Reference to **312340 TUNNEL SUPPORT SYSTEM** is not required and is removed from contract documents.

Sections:

1. Section **312213 MICROTUNNELING**
   a. Replace the entire section on 312213 Tunnel Excavation with new section on 312213 Microtunneling.

2. Section **312230 GRANULAR MATERIALS**
   a. Footer is revised formatted to reflect the correct section number.

3. Section **312319 DEWATERING**
   a. Item 1.3.C – Definition of Professional Engineer is updated to reflect registration specific to the State of New York.

4. Section **313610 ANNULAR GROUT**
   a. Item 1.02.A “312213 TUNNEL EXCAVATION” is revised to “312213 MICROTUNNELING”.
   b. Item 1.02 B is deleted.

5. Section **312340 TUNNEL SUPPORT SYSTEM**
   a. The entire section is deleted. This section is removed from the contract documents.

6. Section **312500 EROSION AND SEDIMENT CONTROL**
   a. Subpart 2.6 revised to read as follows:

      2.6 <u>SILT FENCE</u>
      A. Silt Fence shall conform to the requirements of Section 5 of the New York State Standards and Specifications for Erosion Control.

7. Section **334420 FIBERGLASS REINFORCED POLYMER MORTAR PIPE (FRPMP)**
   a. Item 1.01.A – acronym “FRPM” is revised to “FRPMP”.
   b. Footer is formatted to be consistent.

Appendix A – Geotechnical Baseline Report

The Geotechnical Baseline Report is re-issued.

The specific changes are:

1. **Section 1.1 Introduction**
    a. 2nd paragraph, 1st sentence modified to "This GBR is specifically related to the construction of tunnels and open cut segments to install …".
    b. 2nd paragraph, last sentence modified to "The remaining, approximately, 365 feet will be constructed by open cut."
    c. 3rd paragraph, 2nd sentence modified "This GBR also covers the micro-tunnel and open cut alignment …".
2. **Section 1.2 Project Description**
    a. 1st paragraph, last sentence modified to "A second tunnel segment and an open cut segment will be required …".
    b. 2nd paragraph, list sentence modified to "This second tunnel segment and the open cut segment will be referred to as the 30-inch tunnel and 30-inch open cut respectively".
3. **Section 1.6 Organization of GBR**, 4th bullet, 3rd sentence, "and open cut" is added after "the proposed tunnel".
4. **Section 2.5.2 Clay**, revised.
5. **Section 2.5.3 Hard Clay with Sand Gravel**, modified to read "**Section 2.5.3 Very Stiff to Hard Clay with Sand and Gravel**".
6. **Section 2.5.3**
    a. 1st sentence modified to "The Very Stiff to Hard Clay …".
    b. 2nd sentence modified to "This layer typically consisted of very stiff to hard gray, silty …".
7. **Section 2.5.7 Groundwater**, 1st paragraph, 1st sentence modified to read "Along the open cut segment and along both tunnel segments, the Contractor can anticipate encountering groundwater near the top of the clay stratum or within the fill."
8. The sentence "Fracture spacings of less than 0.3 feet are anticipated." is added to:
    a. **Section 3.1.1 72-in Tunnel Working Shaft**, 2nd paragraph, 2nd to last sentence
    b. Each shaft description for Shaft at Station 0+00, Manhole Structure #2, and Manhole Structure #3 within **Section 3.1.2 30-in Tunnel Shafts**
    c. **Tables 3-3** and **3-4**.
9. Station numbering updated for Shaft - Manhole Structure #4 through Shaft - Manhole Structure #6.
10. **Section 3.4 Open cut Segment – Station 24+57 to Station 26+96** added.
11. **Section 3.4 Tunnel Support System** renumbered to **Section 3.5**; all subsequent section numbers renumbered accordingly.
12. **Section 3.8 Bulkhead** (previously Section 3.7 Bulkhead) revised.
13. **Table 3-9 Open Cut Reach Groundwater Inflow Quantities** added.
14. **Figure 3-8**, Note 1 deleted; Notes 2 and 3 renumbered to Notes 1 and 2
15. Missing **Figure 3-3** added.
16. **Section 4.1 General**
    a. 1st paragraph, last sentence modified to read "The selection of the Contractor's construction methods and equipment for each tunnel segment shaft location and the open cut segment should:".
    b. Bullet 8 added.
17. **Section 4.3.2, 30-inch Tunnel Segment**, last sentence revised.
18. **Section 4.3.3 Open Cut Segment** added.
19. **Section 4.4.1 Selection of Excavation method for 30-inch Tunnel**, last sentence revised.
20. **Section 4.5 Adjacent Structures Protection**

a. 2nd sentence revised to "The allowable ground movements (settlement/heave/deflection) during tunneling, and shaft and open cut excavations operations are provided in the Contract Documents."
b. 3rd sentence revised to "The Contractor is responsible for selecting and implementing means and methods to perform the tunnel, shaft and open cut and shaft work as specified in these Contract Documents …".

21. **Section 4.5.1 72-inch Tunnel**, deleted.
22. Figure 3-1 updated and included as part of the GBR document. See separate attached figure that show clouds where the modifications were made.
23. Figure 3-2 updated and included as part of the GBR document. See separate attached figure that show clouds where the modifications were made.
24. Figure 3-3 updated and included as part of the GBR document. See separate attached figure that show clouds where the modifications were made.

While the ENGINEER has attempted to capture all modifications, all modifications may not have been fully identified in the GBR narrative above. CONTRACTOR/BIDDER shall be responsible for fully reviewing and understanding the revised GBR.

PART III – CLARIFICATIONS/RESPONSES TO CONTRACTOR QUESTIONS

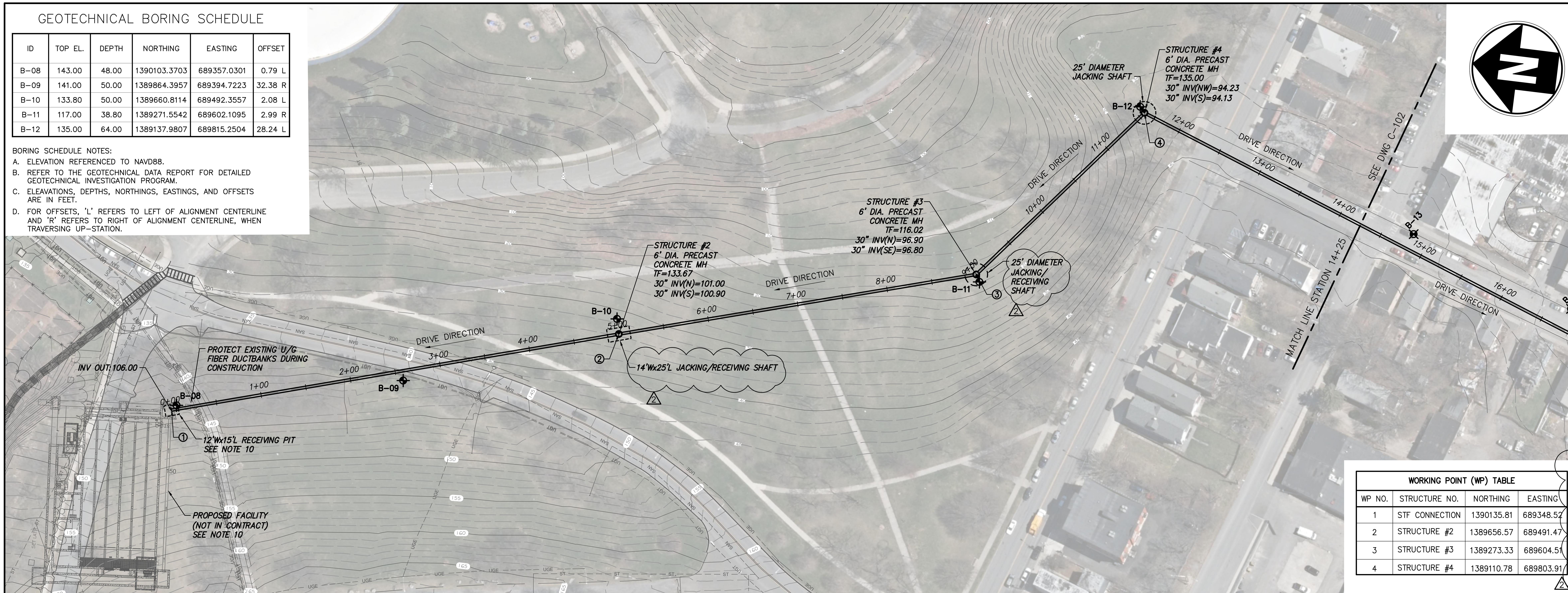
None

PART IV – LIST OF ATTACHMENTS

- Plan Sheet C-101 – 30-IN DIVERSION PIPE PLAN & PROFILE SHEET 1 OF 2
- Plan Sheet C-102 – 30-IN DIVERSION PIPE PLAN & PROFILE SHEET 2 OF 2
- Plan Sheet C-604 – DIVERSION PIPE CASING AND INSTRUMENTATION DETAILS
- Plan Sheet D-700 – WORKING SHAFT SUPPORT OF EXCAVATIN DESIGN REQUIREMENTS
- Section 31 22 13 – MICROTUNNELING
- Appendix A – Geotechnical Baseline Report

END OF ENGINEER'S ADDENDUM

Date: October 13, 2020
Submitted by: Greg Bold, P.E., CDM Smith.



GEOTECHNICAL BORING SCHEDULE

ID	TOP EL.	DEPTH	NORTHING	EASTING	OFFSET
B-08	143.00	48.00	1390103.3703	689357.0301	0.79 L
B-09	141.00	50.00	1389864.3957	689394.7223	32.38 R
B-10	133.80	50.00	1389660.8114	689492.3557	2.08 L
B-11	117.00	38.80	1389271.5542	689602.1095	2.99 R
B-12	135.00	64.00	1389137.9807	689815.2504	28.24 L

BORING SCHEDULE NOTES:

A. ELEVATION REFERENCED TO NAVD88.
B. REFER TO THE GEOTECHNICAL DATA REPORT FOR DETAILED GEOTECHNICAL INVESTIGATION PROGRAM.
C. ELEAVATIONS, DEPTHS, NORTHINGS, EASTINGS, AND OFFSETS ARE IN FEET.
D. FOR OFFSETS, 'L' REFERS TO LEFT OF ALIGNMENT CENTERLINE AND 'R' REFERS TO RIGHT OF ALIGNMENT CENTERLINE, WHEN TRAVERSING UP-STATION.

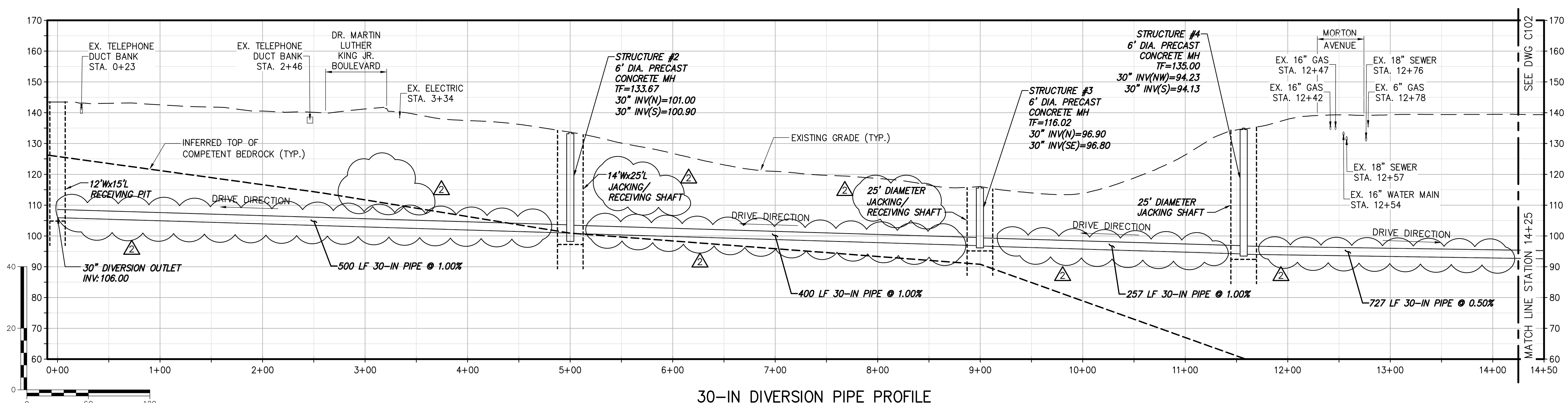
WORKING POINT (WP) TABLE

WP NO.	STRUCTURE NO.	NORTHING	EASTING
1	STF CONNECTION	1390135.81	689348.52
2	STRUCTURE #2	1389656.57	689491.47
3	STRUCTURE #3	1389273.33	689604.51
4	STRUCTURE #4	1389110.78	689803.91

0 60 120
Scale in feet

30-IN DIVERSION PIPE LAYOUT PLAN

SCALE: 1"=60'



30-IN DIVERSION PIPE PROFILE

SCALE: H:1"=60' V:1"=20'

NOTES:

1. CONTRACTOR SHALL MAINTAIN A MINIMUM OF 6'-0" CLEARANCE BETWEEN CASING CROWN AND INLETS OF ANY AND ALL EXISTING UTILITIES.
2. FOR SUBSURFACE CONDITIONS, SEE THE GEOTECHNICAL DATA REPORT.
3. FOR SUBSURFACE STRATA BASELINE CONDITIONS, SEE THE GEOTECHNICAL BASELINE REPORT.
4. CASING LENGTHS ARE ESTIMATE BASED ON ASSUMED WORKING SHAFT LOCATION AND SIZE. CONTRACTOR SHALL BE RESPONSIBLE FOR FINAL DESIGN, LOCATION OF WORKING SHAFTS AND FOR CORRECT CASING LENGTHS.
5. BEDROCK WAS NOT ENCOUNTERED AT BORINGS B-12 THRU B-17.
6. KNOWN UTILITIES SHOWN. CONTRACTOR TO FIELD VERIFY UTILITIES.
7. EXISTING UTILITY LOCATIONS SHOWN IN PLAN AND PROFILE ARE APPROXIMATE.
8. CONTRACTOR SHALL REPAIR ANY AND ALL PARK AREAS, PAVEMENT, SIDEWALK, ETC., DISTURBED DUE TO CONSTRUCTION ACTIVITIES. AREAS SHALL BE RESTORED TO EXISTING CONDITION, OR BETTER, AS APPROVED BY THE OWNER'S ON-SITE ENGINEER.
9. JACKING/RECEIVING SHAFT/PIT SIZES SHOWN ARE MAXIMUM PERMITTED. CONTRACTOR SHALL BE RESPONSIBLE FOR SHAFT/PIT SIZE, LAYOUT, ORIENTATION, DEPTH, ETC.
10. CONTRACTOR SHALL COORDINATE WITH PHASE V CONTRACTOR WHEN TUNNELING BETWEEN STRUCTURE #2 AND STATION 0+00. CONSTRUCTION AND POSITIONING OF RECEIVING PIT AT STATION 0+00 MAY BE IMPACTED BY PHASE V ACTIVITIES.

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SEALS

BID SUBMISSION
NOT FOR CONSTRUCTION

ALBANY WATER BOARD
ALBANY, NEW YORK

BEAVER CREEK CLEAN RIVER PROJECT PHASE IV – THIRD AVENUE TUNNEL

NO.	DATE	ISSUED FOR	BY
2	10/12/2020	ADDENDUM #1	AP-JVT
1	10/6/2020	BID SUBMISSION	AP-JVT

DATE: OCTOBER 2020
PROJECT NO.: 4-G
FILE NAME: 31615_TA_TUNNEL_C101
DESIGNED BY: JW
DRAWN BY: RB
CHECKED BY: MK

SHEET TITLE
CIVIL
30-IN DIVERSION PIPE PLAN & PROFILE SHEET 1 OF 2

SCALE: AS SHOWN

C-101
SHEET 13 OF 28

GEOTECHNICAL BORING SCHEDULE

ID	TOP EL.	DEPTH	NORTHING	EASTING	OFFSET
B-13	139.00	61.00	1388798.2391	689697.8742	2.43 R
B-14	132.00	51.00	1388626.8567	689609.9173	28.51 R
B-15	120.50	51.00	1388435.5879	689559.0643	12.98 R
B-16	97.00	25.00	1388174.9436	689893.8759	10.68 L
B-17	77.50	24.00	1387955.134	690191.9242	17.90 L

BORING SCHEDULE NOTES:

A. ELEVATION REFERENCED TO NAVD88.

B. REFER TO THE GEOTECHNICAL DATA REPORT FOR DETAILED GEOTECHNICAL INVESTIGATION PROGRAM.

C. ELEAVATIONS, DEPTHS, NORTHINGS, EASTINGS, AND OFFSETS ARE IN FEET.

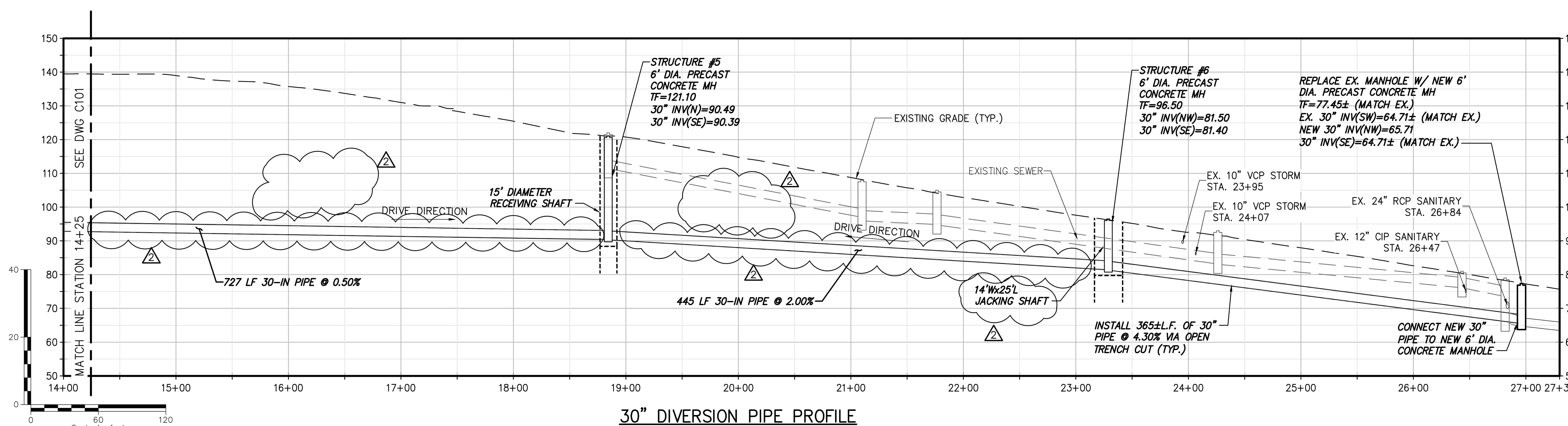
D. FOR OFFSETS, 'L' REFERS TO LEFT OF ALIGNMENT CENTERLINE AND 'R' REFERS TO RIGHT OF ALIGNMENT CENTERLINE, WHEN TRAVERSING UP-STATION.

WORKING POINT (WP) TABLE			
WP NO.	STRUCTURE NO.	NORTHING	EASTING
5	STRUCTURE #5	1388429.45	689549.51
6	STRUCTURE #6	1388156.46	689900.41

0 60 120 Scale in feet

30" DIVERSION PIPE LAYOUT PLAN

SCALE: 1"=60'



30" DIVERSION PIPE PROFILE

SCALE: H:1"=60' V:1"=20'

NOTES:

1. CONTRACTOR SHALL MAINTAIN A MINIMUM OF 6'-0" CLEARANCE BETWEEN CASING CROWN AND INLETS OF ANY AND ALL EXISTING UTILITIES.
2. FOR SUBSURFACE CONDITIONS, SEE THE GEOTECHNICAL DATA REPORT.
3. FOR SUBSURFACE STRATA BASELINE CONDITIONS, SEE THE GEOTECHNICAL BASELINE REPORT.
4. CASING LENGTHS ARE ESTIMATE BASED ON ASSUMED WORKING SHAFT LOCATION AND SIZE. CONTRACTOR SHALL BE RESPONSIBLE FOR FINAL DESIGN, LOCATION OF WORKING SHAFTS AND FOR CORRECT CASING LENGTHS.
5. CONTRACTOR SHALL NOT USE WORKING SHAFT AT STRUCTURE #5 FOR JACKING OPERATIONS.
6. BEDROCK WAS NOT ENCOUNTERED AT BORINGS B-12 THRU B-17.
7. KNOWN UTILITIES SHOWN. CONTRACTOR TO FIELD VERIFY UTILITIES.
8. EXISTING UTILITY LOCATIONS SHOWN IN PLAN AND PROFILE ARE APPROXIMATE.
9. CONTRACTOR SHALL REPAIR ANY AND ALL PARK AREAS, PAVEMENT, SIDEWALK, ETC., DISTURBED DUE TO CONSTRUCTION ACTIVITIES. AREAS SHALL BE RESTORED TO EXISTING CONDITION, OR BETTER, AS APPROVED BY THE OWNER'S ON-SITE ENGINEER.
10. JACKING/RECEIVING SHAFT/PIT SIZES SHOWN ARE MAXIMUM PERMITTED. CONTRACTOR SHALL BE RESPONSIBLE FOR SHAFT/PIT SIZE, LAYOUT, ORIENTATION, DEPTH, ETC.

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ALBANY, NEW YORK

CITY OF ALBANY WATER DEPT.

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SHEET TITLE

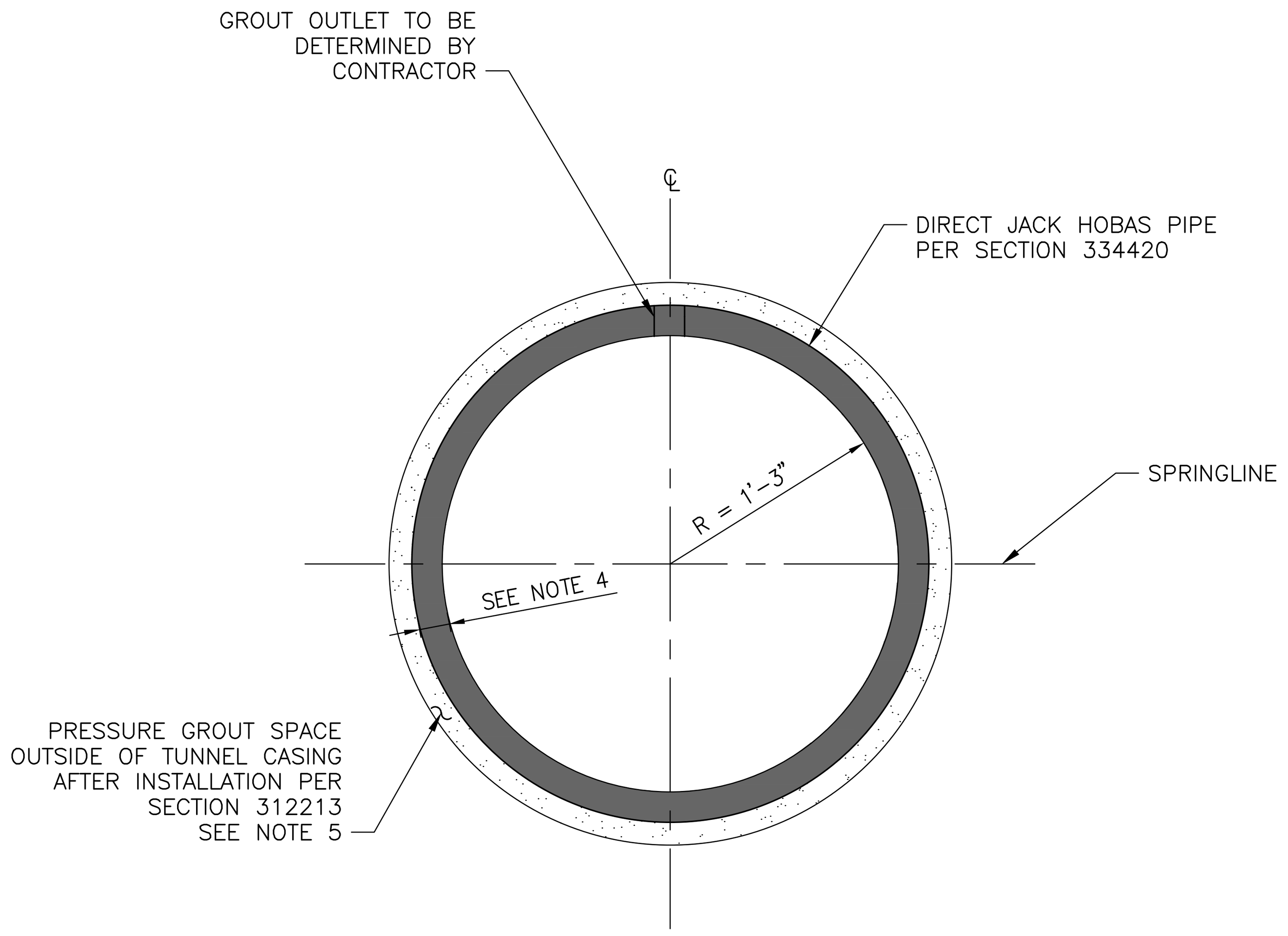
CIVIL

30-IN DIVERSION PIPE PLAN & PROFILE SHEET 2 OF 2

SCALE: AS SHOWN

C-102

SHEET 13 OF 28

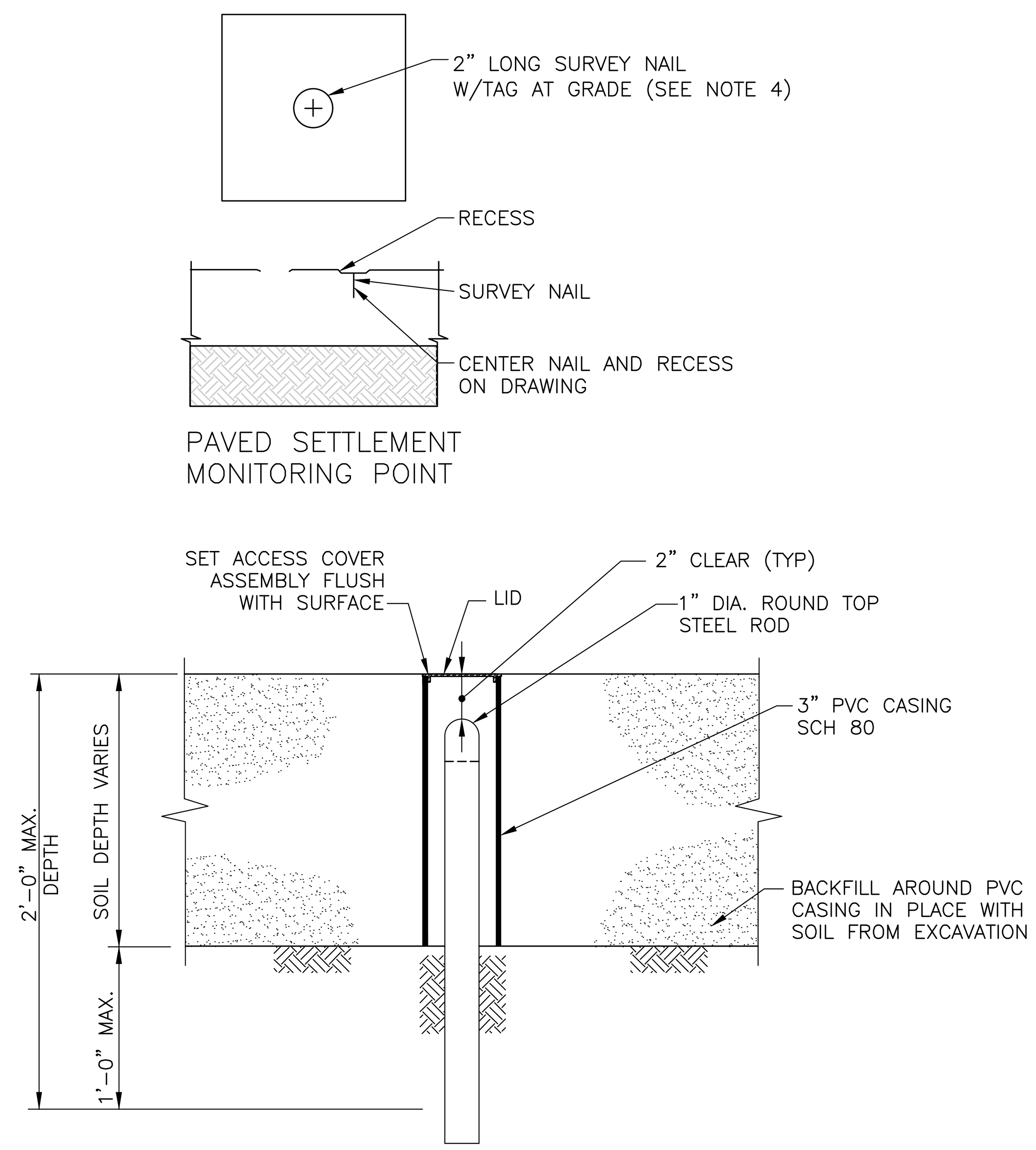


NOTES:

1. EXCAVATED DIAMETER TO BE DETERMINED BY CONTRACTOR.
2. SINGLE-PASS LINER SHOWN.
3. CONTRACTOR SHALL BE RESPONSIBLE FOR DETERMINING THE NEED FOR CASING PER MEANS AND METHODS.
4. CONTRACTOR SHALL DETERMINE PIPE THICKNESS BASED ON INSTALLATION REQUIREMENTS AND MANUFACTURER SPECIFICATIONS.
5. CONTRACTOR SHALL BE RESPONSIBLE FOR DETERMINING THE REQUIRED OVERCUT.

DIVERSION PIPE

DETAIL A
NTS –

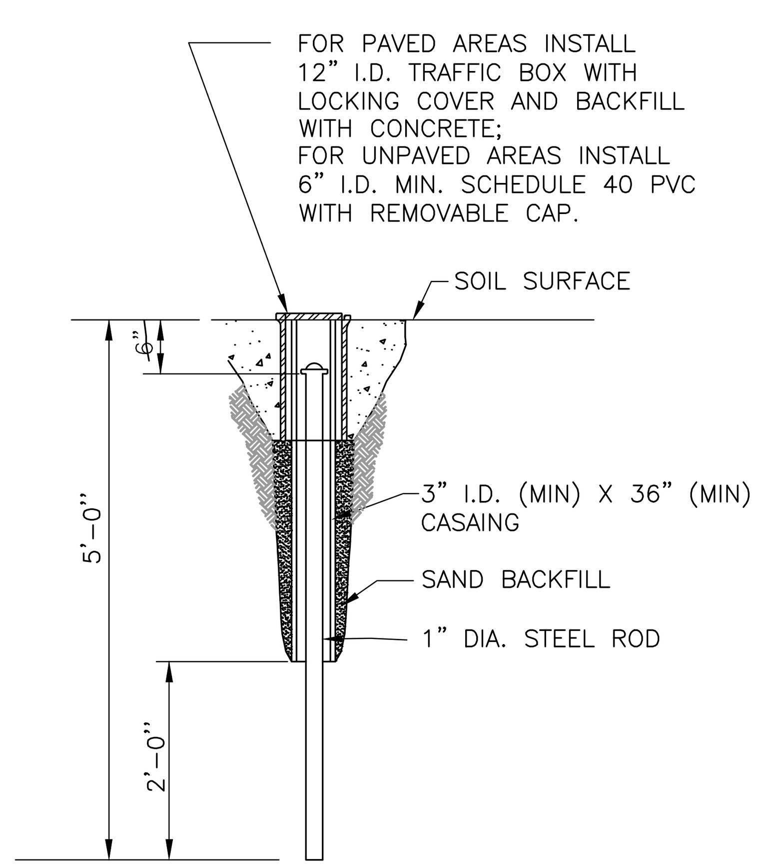


SOIL SETTLEMENT MONITORING POINT (SSMP)

DETAIL B
NTS –

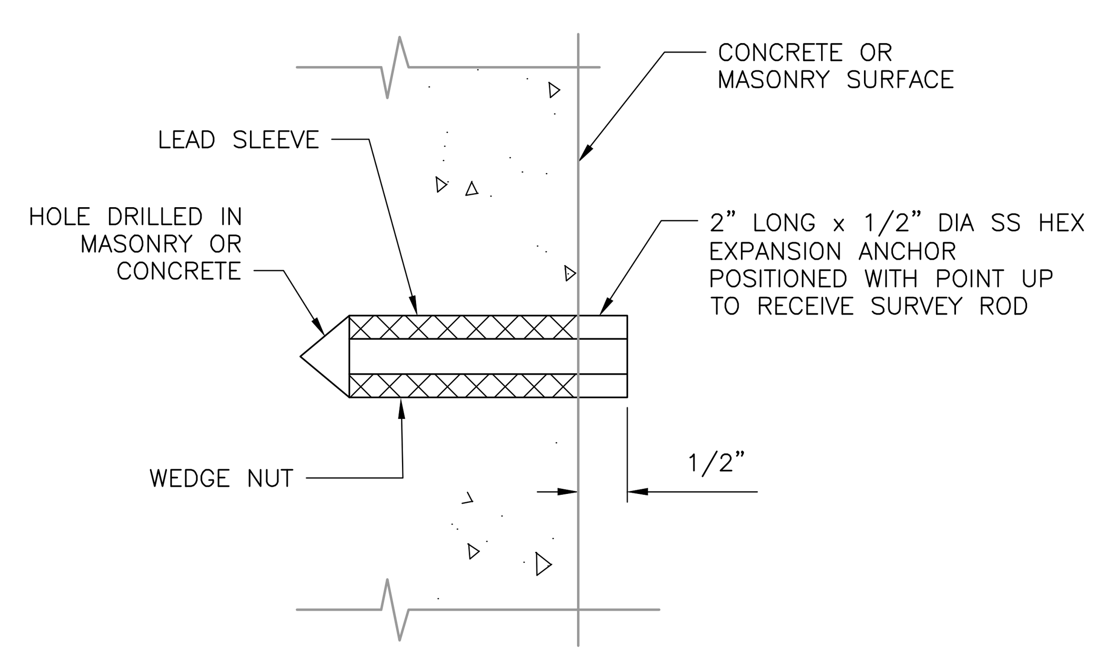
NOTES

1. CONTRACTOR SHALL CARRY IN THEIR BID THE FOLLOWING INSTRUMENTATION ALLOWANCE:
   A. THIRTY (35) UTILITY MONITORING POINTS
   B. TWENTY (20) STANDARD DEFORMATION MONITORING POINTS
   C. TWELVE (12) INCLINOMETERS
   D. FIFTEEN (15) BUILDING DEFORMATION MONITORING POINTS
   E. TEN (10) SOIL SETTLEMENT MONITORING POINTS
2. WHEN TUNNELING UNDER AND ALONG ROADWAY OR SIDEWALK ALIGNMENT, CONTRACTOR SHALL INSTALL STANDARD DEFORMATION MONITORING POINTS ALONG CENTERLINE OF THE TUNNEL ALIGNMENT, AT A SPACING OF 100 FEET.
3. WHEN TUNNELING ACROSS ROADWAY, CONTRACTOR SHALL INSTALL STANDARD DEFORMATION MONITORING POINTS ALONG CENTERLINE OF THE TUNNEL ALIGNMENT, AT THE TWO EDGES OF THE ROADWAY AND AT THE CENTER OF THE ROADWAY.
4. WHEN TUNNELING ACROSS UTILITY, CONTRACTOR SHALL INSTALL UTILITY MONITORING POINT AT THE HORIZONTAL PLANE INTERSECTION OF THE CENTERLINE OF THE TUNNEL ALIGNMENT AND THE CENTERLINE OF THE UTILITY.
5. WHEN TUNNELING UNDER AND ALONG UTILITY ALIGNMENT, CONTRACTOR SHALL INSTALL UTILITY MONITORING POINTS AT SPACING NOT MORE THAN 100 FEET.
6. CONTRACTOR SHALL SUBMIT LOCATIONS, MONITORING SCHEDULE, AND LIMITING AND THRESHOLD VALUES TO THE ENGINEER FOR REVIEW. SEE SPECIFICATIONS FOR MORE DETAILS.



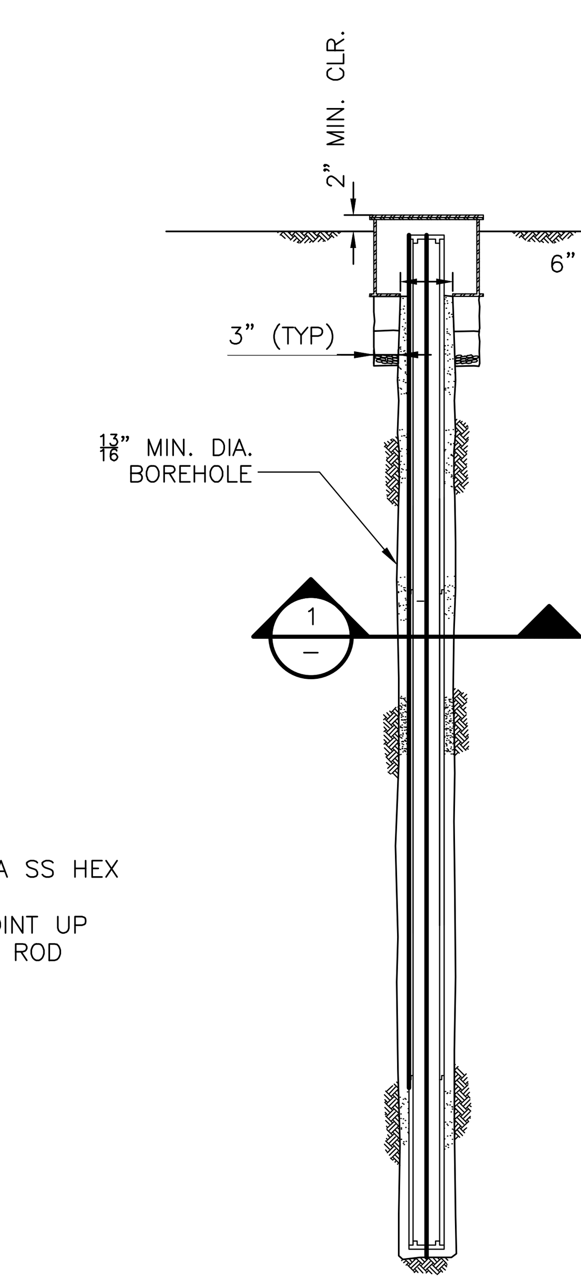
STANDARD DEFORMATION MONITORING POINT (SDMP)

DETAIL C
NTS –

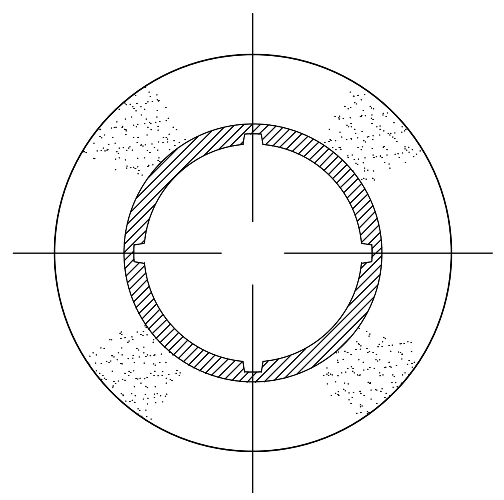


BUILDING DEFORMATION MONITORING POINT (BDMP)

DETAIL D
NTS –



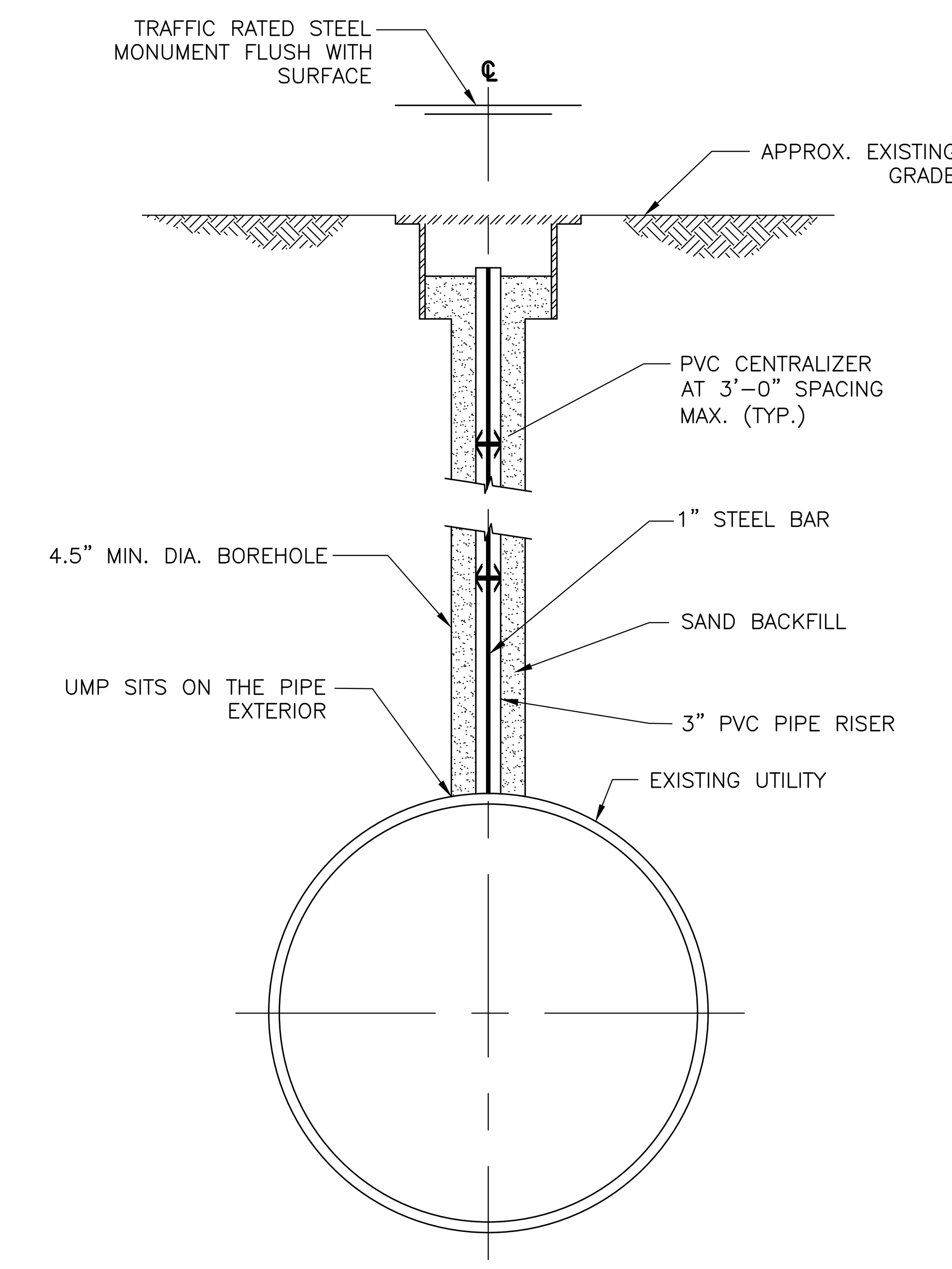
ELEVATION



SECTION 1
NTS –

INCLINOMETER

DETAIL E
NTS –



UTILITY MONITORING POINT (UMP)

DETAIL F
NTS –

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FILE NAME:	31615_TA–TUNNEL_C604
DESIGNED BY:	JW
DRAWN BY:	RB
CHECKED BY:	MK

SHEET TITLE

DIVERSION PIPE, CASING AND INSTRUMENTATION DETAILS

SCALE: AS NOTED

C-604

SHEET 18 OF 28

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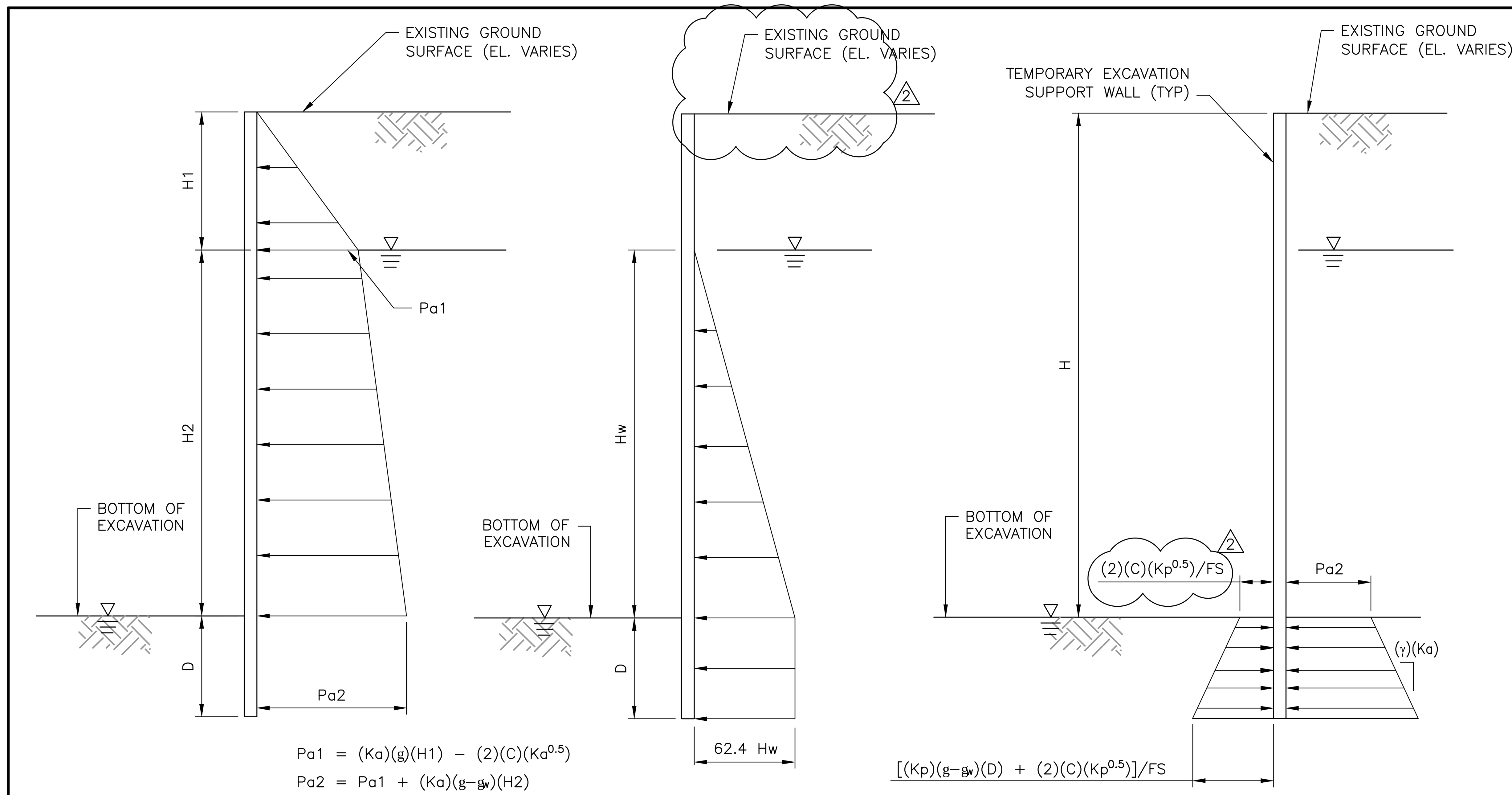


$Pa1 = (Ka)(g)(H1) - (2)(C)(Ka^{0.5})$
$Pa2 = Pa1 + (Ka)(g-g_w)(H2)$

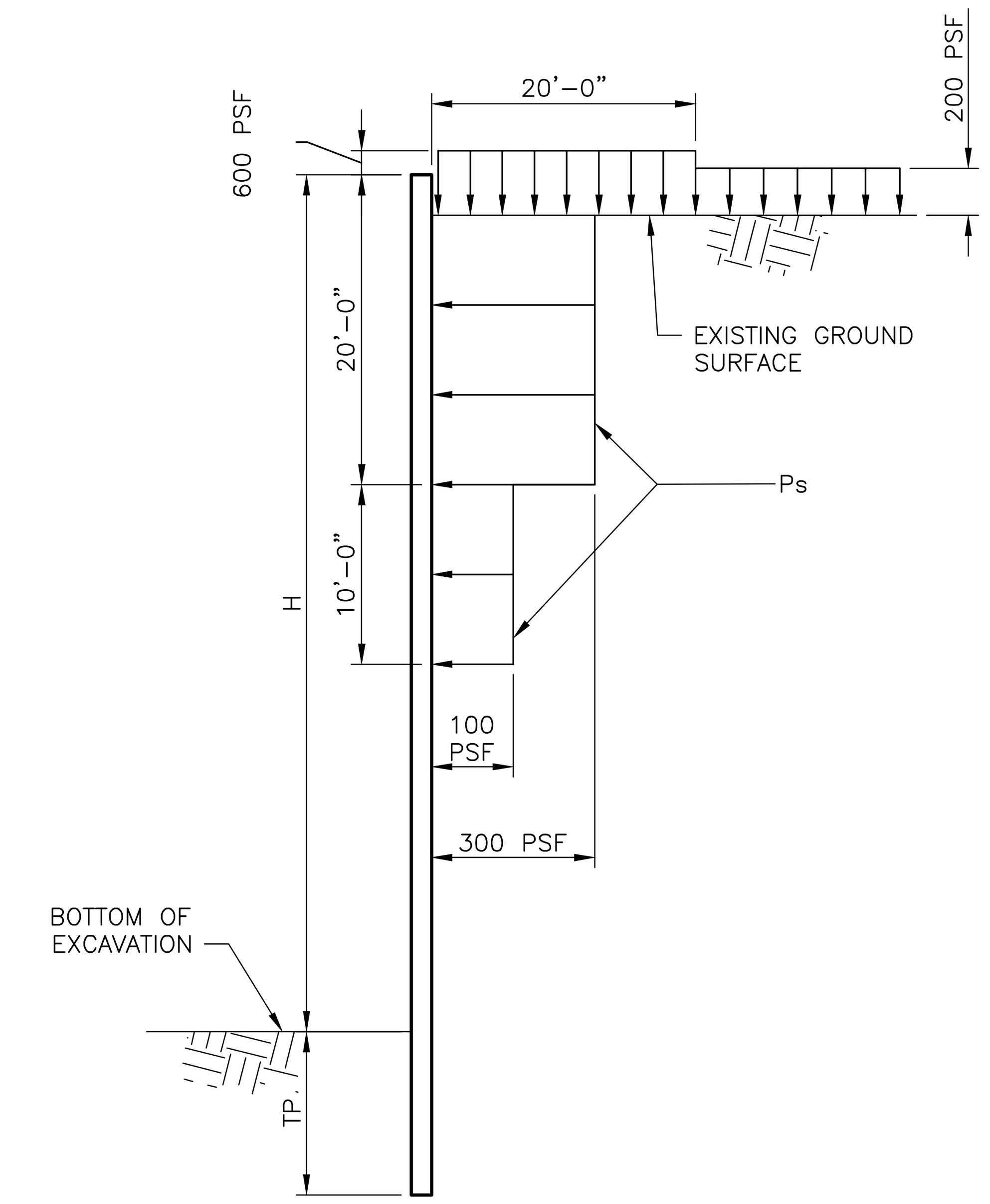
MINIMUM EARTH PRESSURE
NTS

MINIMUM HYDROSTATIC PRESSURES
NTS

MAXIMUM PRESSURE BELOW BOTTOM OF EXCAVATION
NTS

LATERAL EARTH AND WATER PRESSURES – SOIL

DETAIL A
NTS –



SURCHARGE PRESSURES

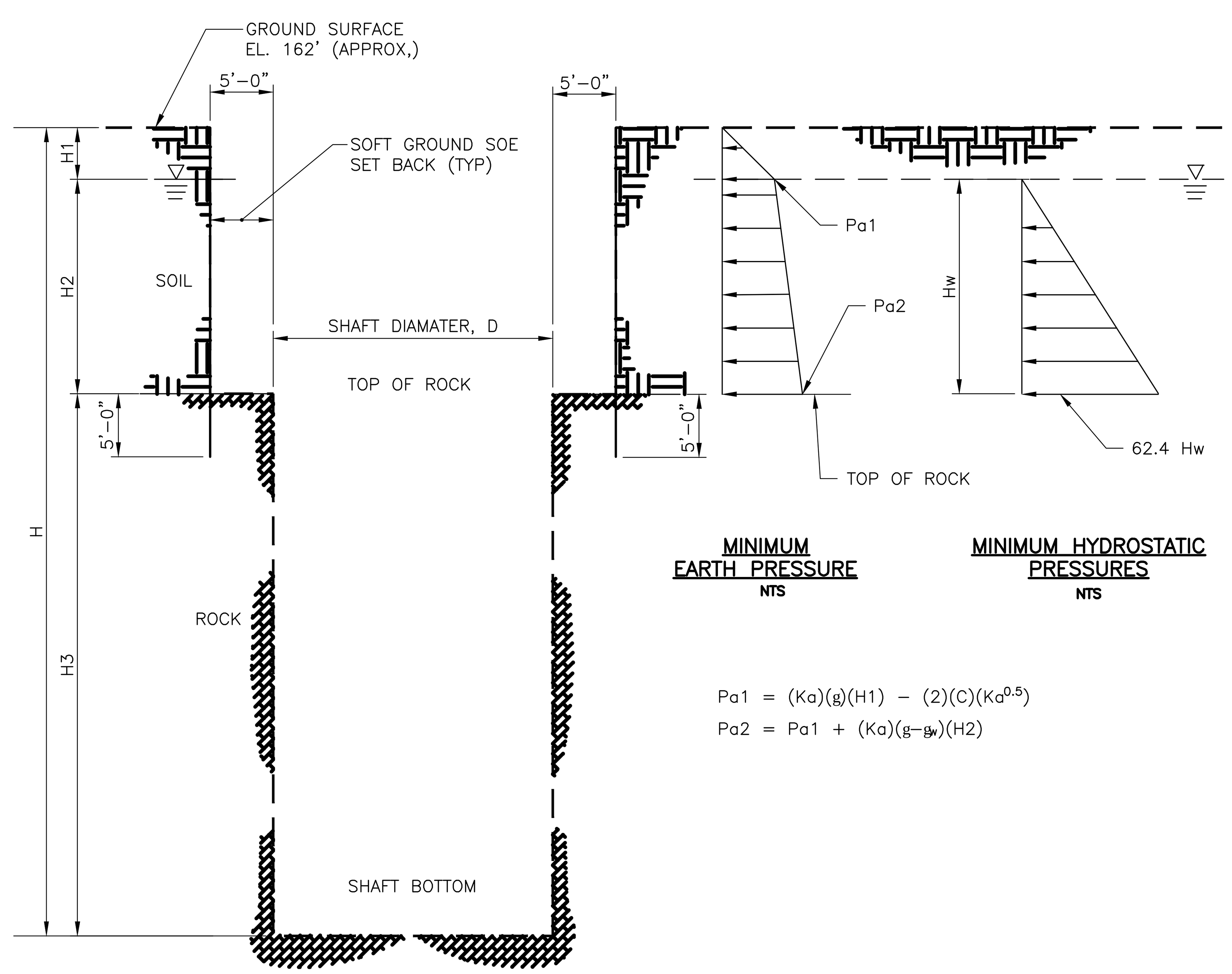
DETAIL C
NTS –

LEGEND:

SYMBOLS:	DEFINITIONS:
g	SOIL UNIT WEIGHT
gw	BOUYANT SOIL UNIT WEIGHT
C	COHESION
FS	FACTOR OF SAFETY (2.0)
GWT	GROUNDWATER TABLE
H	DEPTH OF EXCAVATION TOTAL
H1	DEPTH OF EXCAVATION IN SOIL ABOVE GWT
H2	DEPTH OF EXCAVATION IN SOIL BELOW GWT
H3	DEPTH OF EXCAVATION IN ROCK
Hw	GROUNDWATER HEAD
Ka	ACTIVE CONDITION EARTH PRESSURE COEFFICIENT
Kp	PASSIVE CONDITION EARTH PRESSURE COEFFICIENT
Pa	LATERAL EARTH PRESSURE
Ps	LATERAL SURCHARGE PRESSURE
∇	MINIMUM DESIGN WATER LEVEL

NOTES ON APPLYING DIAGRAMS

1. PRESSURES ARE FOR TEMPOR EXCAVATION SUPPORT SYSTEMS WITH MULTIPLE LEVELS OF BRACING.
2. LATERAL PRESSURES ARE MINIMUM VALUES TO BE USED FOR DESIGN. ADDITIONAL LOAD SHALL BE INCLUDED AS REQUIRED.
3. LATERAL PRESSURES ON ALL TEMPORARY EXCAVATION SUPPORT WALLS SHALL INCLUDE EARTH, AND WATER PRESSURES PLUS TRAFFIC AND EQUIPMENT SURCHARGE. IN ADDITION, FOUNDATION AND STOCKPILING SURCHARGE SHALL BE ADDED AS APPLICABLE TO INDIVIDUAL SECTIONS.
4. PASSIVE TOE PRESSURE USED IN THE DESIGN SHALL NOT EXCEED THE MAXIMUM ALLOWABLE PRESSURE INDICATED, HOWEVER, IT SHALL BE REDUCED AS REQUIRED BY UNIQUE CONDITIONS OR SPECIFIC DETAILS OF THE CONTRACTOR'S DESIGN.
5. REFER TO SPECIAL PROVISIONS FOR BORING LOGS.



MINIMUM EARTH PRESSURE
NTS

MINIMUM HYDROSTATIC PRESSURES
NTS

$Pa1 = (Ka)(g)(H1) - (2)(C)(Ka^{0.5})$
$Pa2 = Pa1 + (Ka)(g-g_w)(H2)$

LATERAL EARTH AND WATER PRESSURES – ROCK

DETAIL B
NTS –

GENERAL NOTES:

1. TEMPORARY EXCAVATION SUPPORT SYSTEMS SHALL BE DESIGNED AND PROVIDED BY THE CONTRACTOR'S ENGINEER IN ACCORDANCE WITH THE CONTRACT DRAWINGS AND SPECIFICATIONS TO THE FINAL DEPTHS AND CONFIGURATIONS AS REQUIRED BY THE CONSTRUCTION CONTRACT, (INCIDENTAL).
2. TEMPORARY EXCAVATION SUPPORT SYSTEMS SHALL BE DESIGNED FOR ALL CONDITIONS THAT CAN OCCUR DURING THE VARIOUS STAGES OF CONSTRUCTION. AMONG OTHERS, THESE CONDITIONS INCLUDE: INITIAL CANTILEVER CONDITION, INSTALLATION, RELOCATION AND REMOVAL OF BRACING, AND SOIL EXCAVATION.
3. TEMPORARY EXCAVATION SUPPORT SYSTEM ELEMENTS CARRYING VERTICAL LOADS AND LATERAL LOADS SHALL BE DESIGNED FOR TENSION AND SHEAR EQUAL TO A MINIMUM OF 10 PERCENT OF THEIR COMPRESSIVE LOAD, UNLESS CALCULATED TENSION AND SHEAR LOADS ARE GREATER.
4. THE TOE OF THE TEMPORARY EXCAVATION SUPPORT SYSTEM SHALL EXTEND A SUFFICIENT DISTANCE BELOW THE BOTTOM OF EXCAVATION IN ORDER TO LIMIT MOVEMENT, PROVIDE ADEQUATE VERTICAL CAPACITY, AND CONTROL GROUND WATER. AT A MINIMUM, THE TEMPORARY EXCAVATION SUPPORT SYSTEM WALL SHALL EXTEND FIVE FEET INTO THE TOP OF BEDROCK.
5. THE FOLLOWING EXCAVATION AND BRACING RESTRICTIONS SHALL BE COMPLIED WITH:
   - 5.A. INITIAL EXCAVATION SHALL NOT EXTEND MORE THAN 8 FEET BELOW THE TOP OF WALL BEFORE THE INSTALLATION OF THE UPPER BRACING LEVEL HAS BEEN COMPLETED.
   - 5.B. THE MAXIMUM VERTICAL SPACING BETWEEN BRACING LEVELS SHALL NOT EXCEED 17 FEET, INCLUDING EXCAVATION TO INSTALL BRACE.
   - 5.C. AT NO TIME SHALL THE VERTICAL DISTANCE FROM THE LOWEST INSTALLED BRACING LEVEL AND THE BOTTOM OF THE EXCAVATION EXCEED 15 FEET.
   - 5.D. DESIGN TEMPORARY EXCAVATION SUPPORT SYSTEM TO ALLOW AT LEAST 2 FEET OF OVEREXCAVATION AT THE BOTTOM OF EXCAVATION WITH NO REDESIGN OR ~~ADDITIONAL SUPPORT.~~
6. CONTRACTOR SHALL USE THE DESIGN PARAMETERS SPECIFIED, OR VALUES INTERPRETED BY CONTRACTOR'S ENGINEER, WHICHEVER IS MORE CONSERVATIVE, TO DEVELOP THE DRIVING AND RESISTING PRESSURES.
7. CONTRACTOR SHALL REFER TO THE GEOTECHNICAL BASELINE REPORT AND THE GEOTECHNICAL DATA REPORT FOR SUBSURFACE STRATA INFORMATION.

LATERAL PRESSURES:

1. DESIGN LATERAL LOADS SHALL INCLUDE EARTH, WATER AND SURCHARGE LOADS
2. WHERE DEWATERING TO LOWER GROUNDWATER LEVELS OUTSIDE OF THE SUPPORT OF EXCAVATION IS PERMITTED AND CONTRACTOR'S DEWATERING APPROACH IS APPROVED, CONTRACTOR MAY REDUCE DESIGN LOADS BY ELIMINATING STATIC GROUNDWATER PRESSURES. IN SUCH CASE, LOWERED GROUNDWATER LEVELS SHALL BE MAINTAINED UNTIL EXCAVATION IS BACKFILLED.
3. ELEVATION SUPPORT SYSTEM IN ROCK IS CONSIDERED TO BE DRAINED (I.e. WITH WEEP HOLES OR OTHER DRAINAGE PROVISIONS)
4. DESIGN OF SUPPORT OF EXCAVATION SHALL BE BASED ON ANALYSIS USING DESIGN EXCAVATION DEPTH PLUS TWO (2) FEET.
5. ELEVATIONS FOR THE TOP OF ROCK ARE PROVIDED IN THE GBR.
6. IF ANY LOADING OCCURS THAT ARE NOT DESCRIBED IN THE CONTRACT DRAWINGS, THEY SHALL BE INCORPORATED INTO THE TEMPORARY EXCAVATION SUPPORT SYSTEM DESIGN

BRACING:

1. DETERMINE LOADS ON BRACING BY USING TRIBUTARY AREA METHOD.
2. SPLICES IN BRACING SHALL BE DESIGNED FOR FULL STRUCTURAL CAPACITY OF THE MEMBER (BOTH IN SHEAR AND MOMENT), USING 100 PERCENT OF AISC ALLOWABLE STRESSES FOR THE CONNECTION.

TOE STABILITY:

1. TO DETERMINE THE EMBEDMENT LENGTH OF THE TOE PENETRATION REQUIRED TO PROVIDE TOE STABILITY, SOLVE FOR THE REQUIRED EMBEDMENT BY MOMENT EQUILIBRIUM ABOUT THE LOWEST BRACING LEVEL. FOR MULTIPLE BRACE LEVEL SYSTEMS, CONSIDER ONLY THE LATERAL PRESSURES ACTING ON THE WALL BELOW THE LOWEST BRACING LEVEL. LATERAL SURCHARGE PRESSURES SHALL BE INCLUDED IF THE SURCHARGE PRESSURE ACTS ON THE WALL BELOW THE LOWEST BRACING LEVEL.
2. TOE PENETRATION REQUIREMENTS FOR MEMBERS OF THE TEMPORARY EXCAVATION SUPPORT SYSTEM WHICH SUPPORT VERTICAL LOADS MAY BE MORE CRITICAL THAN TOE PENETRATION REQUIREMENTS FOR TOE STABILITY AND SHALL BE CONSIDERED IN THE ANALYSIS. IN ADDITION, THE DETERMINATION OF TOE PENETRATION SHOULD CONSIDER THE POTENTIAL FOR SEEPAGE GRADIENTS WHICH COULD CAUSE INSTABILITY AT THE BOTTOM OF THE EXCAVATION. SEEPAGE GRADIENTS SHALL BE TAKEN INTO CONSIDERATION WHEN CALCULATING PASSIVE PRESSURE AS APPLICABLE.

REQUIRED SOIL DESIGN PARAMETERS

STRATUM	TOT. UNIT WEIGHT	EFFECTIVE FRICTION ANGLE	COHESION (C)	EARTH PRESSURE COEFFICIENT	
	PCF	DEGREES	PSF	ACTIVE (Ka)	PASSIVE (Kp)
FILL	120	0	1500	1.00	1.00
GLACIO–LACUSTRINE CLAY	110	0	700	1.00	1.00
GALCIO–LACUSTRINE SAND & GRAVEL	125	34	0	0.28	3.54
WEATHERED SHALE	130	36	0	0.26	3.84

PCF POUNDS PER CUBIC FEET
PSF POUNDS PER SQUARE FEET

albany pool Joint Venture Team

CONSULTANTS

STATE OF NEW YORK MAHMOOD KHWAJA 084232 LICENSED PROFESSIONAL ENGINEER

IT IS A VIOLATION OF LAW FOR ANY PERSON, UNLESS THEY ARE ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, ARCHITECT, LANDSCAPE ARCHITECT OR LAND SURVEYOR TO ALTER AN ITEM IN ANY WAY. IF AN ITEM BEARING THE STAMP OF A LICENSED PROFESSIONAL IS ALTERED, THE ALTERING ENGINEER, ARCHITECT, LANDSCAPE ARCHITECT OR LAND SURVEYOR SHALL STAMP THE DOCUMENT AND INCLUDE THE NOTATION "ALTERED BY" FOLLOWED BY THEIR SIGNATURE, THE DATE OF SUCH ALTERATION, AND A SPECIFIC DESCRIPTION OF THE ALTERATION.

SEALS

BID SUBMISSION
NOT FOR CONSTRUCTION

ALBANY WATER BOARD
ALBANY, NEW YORK

CITY OF ALBANY WATER DEPT.

BEAVER CREEK CLEAN RIVER PROJECT PHASE IV – THIRD AVENUE TUNNEL

NO.	DATE	ISSUED FOR	BY
2	10/12/2020	ADDENDUM #1	AP–JVT
1	10/6/2020	BID SUBMISSION	AP–JVT

DATE: OCTOBER 2020
PROJECT NO.: 4–G
FILE NAME: 31615_TA–TUNNEL_D700
DESIGNED BY: JW
DRAWN BY: RB
CHECKED BY: MK

SHEET TITLE

WORKING SHAFT SUPPORT OF EXCAVATION DESIGN REQUIREMENTS

SCALE: AS NOTED

D-700

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SECTION 312213
MICROTUNNELING

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish all labor, materials, equipment, supplies and incidentals required and install carrier pipe by tunneling, as indicated on the Drawings and as specified, to maintain excavations in a safe manner, to control ground movements, and to protect adjacent structures and roadways, or as otherwise directed by the Engineer or required by agencies having jurisdiction over the Work.

B. Contractor's responsibility shall include but not limited to the following:

1. Responsible for selection of microtunneling equipment including all means and methods subject to review by the Engineer.

2. Furnish labor, equipment, and materials required to complete work by microtunneling including but not limited to; tunneling system and all related accessories, excavation, groundwater control, spoil transportation, separation, removal and disposal, hoisting, lifting, safety, and control equipment.

3. Furnish labor, equipment, and material for launch and receiving shafts construction, complete in place including, but not limited to:
   a. Soil excavation, handling, re-handling and disposal of unsuitable materials, control of groundwater and surface water, utility adjustments/support, tests, excavation, sheeting and shoring, backfilling, cleanup, security, safety barriers. restoration of surface features, other related work necessary for construction as specified and/or as shown on the Drawings.

4. Furnish all labor, materials, equipment and incidentals required and perform tunnel backfill grouting complete after the installation of carrier pipes inside the tunnel, as shown on the Drawings and as specified herein.

C. Furnish the services of a licensed professional engineer registered in the State of New York to prepare shaft and tunneling design as required and specified herein including submittals for review by the Engineer.

Repair any damage associated with movement or settlement exceeding the threshold values as specified in Section 310900 for the existing structure, utility, or road over, along or adjacent to the work. When the threshold value is exceeded the structure, utility or roadway shall be inspected for damage and all necessary precautions shall be taken to prevent further movement, settlement or damage. If damage to an existing structure, pavement, or utility is observed, the Engineer may order all work to be immediately stopped except that which assists in making the work secure and in preventing further movement, settlement or damage. Repairing the damage shall be at the Contractor's own cost and to the satisfaction of the Engineer.

D. Follow all OSHA regulations regarding confined space for casing installation. Obtain all permits required associated with OSHA regulations and requirements for confined space entry.

E. Furnish special insurance, traffic control, flaggers and any other requirements imposed by the owner of the rights of way over the work.

F. Conform to all requirements of the permit for work within City of Albany rights-of-way.

G. Blasting shall not be allowed.

1.02 RELATED SECTIONS

A. Section 012900 – Payment Procedures

B. Section 013300 – Submittal Procedures

C. Section 312319 - Dewatering

D. Section 315000- Excavation Support and Protection

E. Section 312333 – Trenching Backfill and Compaction

F. Section 310900 - Geotechnical Instrumentation and Monitoring

1.03 DEFINITIONS

A. Tunnel: an underground opening supported using tunnel casing.

B. Casing Pipe: A steel pipe installed behind the microtunneling machine, which is jacked into place, within which a carrier pipe is inserted later.

C. Carrier pipe: The pipe inserted within the steel casing pipe and which acts as the conveyor for water.

D. Microtunneling: An underground method of construction by jacking a pipe behind a steerable, laser-guided articulated mechanical cutting shield, with a pressurized face to support the tunnel excavation heading or other means and method(s) as approved by the Engineer.

E. Launch Shaft: Working shaft used for access for advancing of tunnel, muck removal, pipe installation, etc.

F. Receiving Shaft: Working shaft used for equipment retrieval.

G. Drive: Section of pipe installed by microtunneling from launch shaft to receiving shaft.

H. Slurry Pressure Balance System

1. Pressurized tunneling system that mixes excavated material with slurry in a chamber located behind cutting head.

2. Low pressure slurry is used to balance ground and water pressure at face of tunnel, limit settlement and to convey cuttings back to ground surface.

3. Cuttings are removed or separated, and slurry is re-circulated back to the tunnel face.

I. Spoil: Excavated soil and bedrock material that has been mixed with either water or slurry and pumped to surface to be separated and recycled or disposed.

J. Admixtures: Materials other than water, aggregate, or cement added to the grout mix to modify the mix properties.

K. Foam: A synthetic foaming agent which when added to engineered cement slurry enables the production of cellular lightweight concrete.

L. Low Density Cellular Concrete (LDCC): A lightweight cementitious material that contains stable air or gas cells uniformly distributed throughout the mixture of a volume percentage greater than 20 percent.

M. Structural Grout Backfill: Low-shrink, fluid, unreinforced grout designed to fill the annual space between the carrier pipe and the excavated rock surface or the casing pipe.

1.04 QUALITY ASSURANCE

A. Regulations: Perform all work in accordance with current applicable regulations and codes of all Federal, State, and local agencies.

B. The tunneling contractor shall have at least five (5) years of experience with compatible work to the Work shown and specified, employing labor and supervisory personnel who are similarly experienced in this type of work and shall have installed a minimum of 1,000 linear feet of pipe by tunneling. Compatible work shall include tunneling of at least one (1) tunnel below groundwater table with a minimum 54-inch diameter and a minimum of 700 feet long. A minimum of three (3) projects performed within the past five (5) years shall be presented including date of project, location, excavation type, tunnel diameter and length, responsible personnel, client and contact address and phone number, size of job in dollars, and performance.

C. Supervision

1. Supervised by at least 1 person with 5 years of recent previous experience in similar tunneling process.

2. Experience in completion of a minimum of three (3) pipeline projects; each with a minimum drive of 700 L.F. of installed pipe of at least 54 inches inside diameter using similar tunneling methods; and completed in the 10 years prior to the bid date.

3. Tunneling operations shall be performed under the constant direction of a microtunneling supervisor who shall remain on site and be in responsible charge throughout the tunneling operation.

D. Operators

1. Experience requirements are; the construction and completion of a minimum of three (3) pipeline projects; each with a minimum of 700 L.F. of installed pipe of at least 54 inches inside diameter using pressurized face tunneling methods; and completed in the 10 years previous to the bid date. The operator shall also have:
   a. Operated equipment similar to the proposed equipment.
   b. Utilized the same type of pipe material as used for the tunneling work on this project.
   c. Successfully completed a project in similar ground conditions to those contained in the Geotechnical Baseline Report (GBR), including, but not limited to: soil type, soil strength as measured by "N" values, and hydrostatic head.
   d. Successfully completed a tunnel of a drive length at least 100% of the longest drive length required for this project.
   e. Successfully completed a tunnel of an outside diameter at least 100% of the outside diameter required on this project.

E. Experience Record

1. For the above items, the experience record shall also include a listing that indicates the most recent ten (five for the Project Superintendent) microtunneling projects and all projects demonstrating the required experience. The experience record shall include name of project, the agency that contracted for the project, name of contact including all contact information, carrier pipe material, carrier and casing pipes outside diameters, subsurface conditions, longest drive planned and completed, and total footage planned and completed. If the microtunneling work was performed as a subcontractor, the record shall include name of general contractor, name of contact, and all contact information.

F. Tunnel Engineer

1. Experience requirements are; professional engineer licensed by the State of New York having an experience record demonstrating qualifications for designs and calculations to be performed. Experience record shall include the five most recent tunneling projects. The experience record shall include name of project, the agency that contracted for the project, name of contact including all contact information and the record shall include name of general contractor, name of contact, and all contact information.

G. Surveyor

1. Experience requirements are; professional surveyor licensed by the State of New York; and an experience record demonstrating underground surveying experience including the transfer of points and line from the surface to below surface. Experience record shall include the most recent five tunneling projects. The experience record shall include name of project, design tolerance, results of as-built survey, the entity that contracted for the services including name of contact, and all contact information, and the name of project owner including name of contact, and all contact information.

H. Operation

1. Operate systems following manufacturer's instructions.

2. Make available at all times copies of operations manuals to The Engineer and operational personnel on-site.

I. Drive Start Up

1. Before commencement of any drive, demonstrate to the Engineer that required set up procedures and system checks are complete and required materials are at hand to commence drive.

2. Do not commence drive until construction of receiving shaft has been completed.

1.05 QUALITY CONTROL

A. Operation

1. Run Test: Test full system on completion of set up and before commencing drive.

2. Engineer shall be allowed access to manually record the operating parameters during the tunneling operations such as pitch, roll, yaw, guidance system information, valve positions, thrust force, cutterhead torque, rate of advance and installed length of pipe. Access to this information shall be provided either by admitting the Engineer into the control cabin to record the data or else by setting up an electronic monitor display of the same information as that displayed by the operator control console. This monitor shall be located in a suitable shelter in the vicinity of the launch shaft. Also, provide the Engineer with access to manually record the pressure gauge, volumetric gauge, and position of the shut-off valve for the lubrication system during the microtunneling operations.

3. Engineer shall be allowed access to annular space grouting operations to record the pressure gauge, volumetric gauge, and position of the shut-off valve.

B. Materials

1. Engineer shall be allowed access to the materials for inspection. The Contractor shall assist the Engineer, as needed, to present these materials for inspection.

2. Casing pipe shall be the product of a single domestic manufacturer. Casing pipe shall be tested and inspected at the manufacturing plant as required by the standard specifications to which the material is manufactured.

3. Defective materials: Any material found to be defective shall be immediately marked “DEFECTIVE – NOT FOR USE”. This marking shall be clear from any point of view and shall be permanent. The defective material shall then be transported offsite and disposed.

1.06 SUBMITTALS

A. Submit in accordance with Section 01300.

B. If modifications are required during construction, submit for approval information illustrating such modifications, including reasons.

C. Tunneling Qualifications for Contractor Performing Microtunneling Work:

1. Cover sheet: Date, company name, address, telephone and fax numbers, email address, and contact person.

2. Resumes of managerial, supervisory and operational key personnel: Detailed descriptions of their tunneling projects.

3. Summary sheet of previous projects performed using similar tunnel methods that demonstrates expertise and experience. Named projects may be used more than once under separate paragraphs if their criteria apply.

4. Submit for each named project above, and in same order, following detailed information:
   a. Date, full name of project, and location.
   b. Owner's name, address, telephone and fax numbers, email address, and contact person.
   c. Client's name, address, telephone and fax numbers, and contact person.
   d. Employees in charge of work at both head office and site.
   e. Description of relevant work successfully completed, including ground conditions.
   f. Features under which pipe passed, depth below the water table, photos, and published articles if available.
   g. Additional information as necessary or requested.

D. Equipment

1. Submit full details of tunneling system to be employed.

2. Manufacturer and date(s) of manufacture and any equipment refurbishments.

3. Type and model number for whole system if from single source or separate details for each element of system.

4. Confirmation from manufacturer that machine set up is suitable to limit annular space, as specified, for external diameter of pipe proposed.

5. System of alignment monitoring and steering control and activation.

6. Hydraulic jacking system maximum capacity and method of limiting jacking capacity to that of maximum capacity of specified casing.

7. History of repairs/servicing.

E. Procedures

1. Submit full details of procedures and resources that will be employed to carry out work including method and sequence of:
   a. Establishment of drive line and elevation at base of shaft.
   b. Pipe handling and connections.
   c. Maintaining line and grade, and re-establishment of line and grade as required.
   d. Spoil separation and disposal.
   e. Groundwater control.
   f. Spoil and slurry containment during microtunneling work.
   g. Installation of carrier pipe, including placement of grout between carrier pipe and the casing pipe or the ground.

F. Materials

1. Submit full details of following materials:
   a. Design mixes for all concrete, grout. Provide certification that admixtures are non-toxic.
   b. Test results for each concrete and grout mix performed in accordance with ASTM C 796.
   c. Casing pipe (if proposed to be used) including manufacturer, grade, and specification, outside diameter, thickness, and any coatings, if required.

G. Calculations signed and sealed by the Contractor's Profession Engineer that clearly state:

1. Maximum calculated jacking resistance for installing complete pipe string between the launch and receiving shafts.

2. Maximum allowable face pressure or slurry pressure that can be exerted at tunnel face without fluid loss to surface, other structures or features or heave of ground.

3. Relationship between hydraulic jacking pressure and force applied to the pipe during jacking.

4. Casing pipe thickness and deformation during installation.

5. Calculations for preventing floatation and deformation of the carrier pipe during backfill grouting to fill annular space between the carrier pipe and casing pipe.

H. Launch and Receiving Shafts

1. Submit station specific Working Drawings to include, but not limited to:
   a. Launch and receiving shaft configurations.
   b. Design and construction of launch and receiving shafts.
   c. Details for excavation support system.
   d. Special requirements for launch and receiving shaft penetrations, thrust blocks, backstops or other reactions required for Microtunneling.
   e. Full calculations supporting maximum jacking capacity that launch shaft will withstand without movement exceeding 0.5 inches with an appropriate factor of safety.

f. Areas for storage, material and spoil handling, water control, ground stabilization if required, excavation procedures, and backfilling with CSLM.
g. Surface water and groundwater control plans for the launch and receiving shafts.
h. Temporary lighting and electrical provisions.
i. Refer to Section 02311 for additional requirements.

I. Other Contingency Plans: Detailed contingency plans are required for the following:

1. High jacking forces.

2. Damaged pipe.

3. Obstruction(s).

4. Removal of boulders.

5. Settlement.

6. Loss of line and grade.

7. Major mechanical breakdown.

8. Stoppage of jacking.

9. Loss of cutter tools on the cutter head of the microtunneling boring machine (MTBM).

10. Maintain line and grade during mixed face conditions.

J. Submit the Contractor's New York professional engineer's qualifications as described herein.

K. Daily Reports

1. Daily surveyor reports of casing pipe position and control point monitoring, conducted by the Contractor's surveyor, shall be provided in writing to the Engineer.

2. Daily activity log of the tunnel installation progress.

L. Working Drawings and Method Statements for tunnel backfill grouting including:

1. Means and method for proportioning, mixing, batching and delivering grout, including storage of raw materials.

2. Method statements and design calculations for placing materials, including rate of placement based upon maximum height of grout allowed prior to set to prevent overloading of the carrier pipe.

3. Details for transporting and placing grout.
   a. Describe the sequencing of this work with the installation of the carrier pipe and provide the following:

1) Drawings showing details of grout delivery pipes, slicklines, injection ports, bulkheads, vent outlets, and other materials.
2) Calculations for preventing floatation and deformation of the carrier pipe during installation and grouting.
3) Description of labor, equipment and supplies required to perform the work.
4) Cross-section and profiles showing the arrangement of transportation, handling, and placing equipment including passing clearances.
5) Details of pumping pressures and rates, placement sequences and volumes, lift thicknesses, including theoretical quantity for each placement.
6) Methods for diverting construction water and groundwater and protecting the grout.
7) Methods for handling the materials prior to placing the grout within the annulus, including agitators, remixer or other equipment.
8) Methods for blocking or bracing the carrier pipes during grouting.
9) Methods of controlling lift heights or rate of placement of grout within the requirements stated herein.
10) Methods for maintaining uniformity of the grout elevation around the carrier pipe.

Method statements and design calculations for grouting including grouting pressure and volume of grout placed.

M. Mix design report for tunnel backfill grouting including:

1. Mix type and designation.

2. Mix constituents and proportions, including materials by weight and volume.

3. Mix densities and viscosities, including materials by weight and volume.

4. Initial set time of mix.

5. Bleeding, shrinkage/expansion.

6. Compressive strength.

N. Quality Control for tunnel backfill grouting

1. Qualifications: Field sampling and testing personnel, including qualifications of employer.

2. Certifications for the following:
   a. Calibration certificates for gauges, scales, and meters in accordance with ANSI B40.1.
   b. Written certification from the carrier pipe manufacturer that the pipe is capable of handling the proposed pumping and hydrostatic pressures, and heat generated during hydration from annular backfill material.

3. Quality Control Plans
   a. Procedures for producing backfill, including procedures for verifying mix ingredient quality and performing sampling, testing, and record keeping.
   b. Methods for controlling critical mix parameters.

c. Methods for assuring that the annular space between the carrier pipe and the excavated surface are completely filled.
d. Methods for assuring that injection pressures do not damage the carrier pipe or adjacent work.

4. Record Keeping. Daily Records submitted no later than the end of each working day to the Engineer are to include:
   a. Scale weights for batched loads.
   b. Mix design tickets.
   c. Delivery tickets.

5. Contractor shall notify the Engineer two week prior to beginning the placement of backfill.

O. Record drawings

1. Maintain at the construction site a complete set of field drawings for recording of as-built conditions.

2. Mark or note thereon up-to-date as-built conditions properly dated.

1.07 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM A36 - Standard Specification for Carbon Structural Steel.

2. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

3. ASTM A1097 - Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded (Outside Diameter of 10 in. and Larger).

4. ASTM C144 - Standard Specification for Aggregate for Masonry Mortar.

5. ASTM C150 - Standard Specification for Portland Cement.

6. ASTM C311 - Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete.

7. ASTM C494 - Standard Specification for Chemical Admixture for Concrete.

8. ASTM C495 - Compressive Strength of Lightweight Insulating Concrete.

9. ASTM C567 - Unit Weight of Structural Lightweight Concrete.

10. ASTM C618 - Fly Ash and Raw Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

11. ASTM C796 - Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam.

12. ASTM C869 - Foaming agents Used in Making Preformed Foam for Cellular Concrete.

13. ASTM C937 - Standard Specification for Grout Gluidifier for Preplaced – Aggregate Concrete.

B. Occupational Safety and health Administration (OSHA):

1. 29 CFR Part 1926, Subpart S, Regulations and Standards for Underground Construction.

C. American Society of Civil Engineers (ASCE):

1. Standard Construction Guidelines for Microtunneling CI/ASCE 36-01.

D. National Electric Code (NEC):

1. NFPA70.

E. Where reference is made to one the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

2.02 MATERIALS

A. Casing Pipe

1. Steel Casing Pipe: Smooth walled with minimum yield strength of 36,000 psi (ASTM A1097 Grade 36).

2. Steel pipe casing shall be furnished in lengths of the Contractor’s choice.

3. Casing shall have 2-inch grout holes such that grout ports are provided at 5-foot maximum intervals along the length of the completed casing circumferentially and placed at 120 degrees on centers (three holes at each interval) orientated with one hole at the crown. Two-inch steel half-couplings shall be welded over the holes in the casing and shall have threaded steel plugs.

4. The casing shall have beveled ends with a single or double v-groove and joints shall be fully welded around circumference of pipe or be equipped with Permalok connectors. The casing connection shall be of sufficient strength to withstand all forces at pipe joints without any

distortion of pipes. The finished tunnel shall be watertight (except minor seepage) under prevailing groundwater conditions prior to installation of the carrier pipe.

5. No coating is required on casing pipe.

B. Grout to fill annular space between casing pipe and the ground:

1. Cement: ASTM C150, Type II.

2. Water: Potable free of deleterious material.

3. Sand: ASTM C404, Size No. 1.

4. Design mix for grout: Minimum compressive strength of 100 psi attained within 24 hours. The grout shall be readily pumpable.

C. Grout to fill annular space between carrier pipe and the casing pipe:

1. Grout backfill for the annular space between carrier pipe and casing pipe shall be either structural grout backfill or low density cellular concrete.

2. Cement: ASTM C150, Type II.

3. Contractor shall not use admixtures containing chlorides that promote corrosion. Admixtures shall be non-toxic.

4. Retarder/Water reducer shall conform to the requirements of ASTM C494, Type D.

5. Plasticizer/Water Reducer shall conform to the requirements of ASTM C494, Type A.

6. Fly Ash shall be Type F conforming to ASTM C618. Fly ash/cement ratios shall not exceed 1.0 by weight.

7. Sand shall conform to ASTM C144, except as modified herein and shall consist of clean, hard, durable grains of approved inert materials. Sand shall be well graded to attain a fineness modulus between 1.50 and 2.00. It shall also meet the following requirement:

Sieve Sizes	Percentage Passing by Weight
No. 16	95
No. 200	Not More Than 5

8. Water shall be potable, clean and free from deleterious amounts of acids, alkalis, oils, or organic matter with a pH not less than 6.7.

9. Grout admixtures may be used subject to the approval of the Engineer to improve pumpability, control time of set, hold sand in suspension, and to reduce segregation and bleeding.

10. Grout mixture proportions shall be such as to provide continuous efficient flow to fill all spaces required to be filled.

11. Foaming agents shall comply with ASTM C 869 when tested in accordance with ASTM C 796.

12. Mix Design
    a. Structural Grout Backfill shall consist of a mixture of water and Portland cement, at a water to cement ratio by weight of 1:1, and admixtures conforming to this Section, additional provisions for controlling set times and anti-washout admixtures to prevent washout of the cement paste. The minimum compressive strength of the structural grout backfill shall be 400 psi at 28 days.
    b. Low Density Cellular Concrete mix shall be designed in accordance with the requirements of ACI 523.1R, ACI 523.3R and the additional requirements specified herein. Mixes shall be adjusted in the field as necessary to meet the requirements of these specifications. The foaming agent material manufacturer’s field services representative shall approve all changes to the mix designs.
        1). Minimum 28-day compressive strength (ASTM C495): 200 psi.
        2). Wet Density: Wet Density (unit weight) of LDCC shall not be less than 50 pcf, plus or minus 5 pcf, at the point of placement, unless a higher density is required to achieve strength requirements. Determine unit weight of each proposed batch in accordance with ASTM C 567.
        3). Foam shall retain its stability until the cement sets to form a self-supporting matrix. The resulting LDCC shall have essentially closed cell and low water absorptive characteristics. The concentration of the foaming agent shall be in accordance with the foaming agent material manufacture’s recommendations.
        4). The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer’s recommendations for minimum shrinkage.
        5). A test mix shall be designed and tested in accordance with ASTM C 796 for each consistency intended for uses.

2.03 EQUIPMENT

A. Tunneling System

1. Closed face machine capable of excavating a mixed face condition, providing positive supporting pressure to full excavated area (face) at all times and capability of controlling and measuring pressure at face.

2. Achieve balancing of earth and ground water pressures by use of slurry pressure, auger earth pressure balance or a combination of the two.

3. System capable of any adjustment required to maintain face stability for anticipated ground and groundwater conditions.

4. Control slurry pressure systems, using slurry spoil transportation, and earth and groundwater pressure at the face by use of variable flow slurry pumps, pressure control valves and minimum of 2 flow meters, 1 on feed side and 1 on return side.

5. The tunneling system shall be capable of excavating, cutting, crushing, cobbles and boulders as described in the GBR.

6. Ability to control axial rotation to within 3-degrees of normal operating datum.

7. Ability to articulate and steer to correct vertical and horizontal deviation from alignment datum by remote activation, in a manner that will control the advance of the heading while maintaining line and grade within the specified tolerances.

8. Means to inject lubricant over lead pipe, if required.

9. Spoil transportation system that has capacity for removal of spoil in balance with excavation and advance.

10. Main launch shaft capable of exerting uniform load to casing pipe at a speed commensurate with speed of excavation advance.

11. Set jacking hydraulics to relieve pressure at maximum safe working capacity of the pipe.

B. Spoil separation system:

1. Spoil separation system with sufficient capacity to remove solids from flow while system is excavating spoil.

2. Operates in such a manner that re-circulated or excess fluid can be discharged safely and with negligible remaining fines.

C. Backfill Grouting

1. Contractor shall provide all necessary equipment to manufacture, deliver, convey and place the backfill. Contractor shall use equipment for mixing and injecting backfill which is designed for underground backfill grouting service.

2. Equipment shall be maintained in good operating condition, capable of satisfactory mixing, agitating, and placing backfill at a uniform rate under the required pressure.

3. Batching, mixing and pumping equipment shall be compatible and of sufficient size and capacity to place backfill to distances and volumes proposed by the Contractor. All pumping equipment shall be operated so that a continuous stream of backfill is conveyed to the backfill location. An adequate inventory of spare parts or backup equipment shall be provided to ensure that operable backfill grouting equipment is available at all times during the work.

4. Hoses or pipes of proper type and diameter shall be used to withstand maximum injection pressures used.

5. At the point of injection, suitable valves and calibrated pressure gauges shall be provided so that the pressure and grout flow at the grout port may be regulated and monitored. Provide at or very near the point of injection, a system of valves in the line transporting the grout that will easy access for collection of test specimens. Provide an automatic bypass valve set to the maximum pressure.

6. Vent pipes shall be placed through the tunnel lining at high areas of the crown to provide for venting of entrapped air and water.

7. A foam generator shall be used for production of Low Density Cellular Grout annular backfill. The foam generator shall be capable of producing a predetermined quantity of preformed foam which shall be injected into the mixer and blended with the cement slurry.

   The foam generator shall be timer controlled to repetitively discharge preselected quantity or to discharge continuously at a fixed rate. Foam generating equipment shall be tested and calibrated for dilution percentage, density, and volume output. Two types of foam generating systems, batch and continuous generating, are acceptable.

PART 3 EXECUTION

3.01 SURFACE WATER AND GROUNDWATER CONTROL

A. Develop and maintain a system for control of surface water and groundwater, keeping excavations free of water until backfill operation is in progress. Groundwater and surface water control system shall meet the requirements of Section 02140 Dewatering and Drainage.

B. Grade the ground surface to preclude surface water runoff into the excavations. If the Contractor's work plan requires construction of the shafts within the limits of the stream floodway, water elevation up to the 100-year flood elevation shall be anticipated. If the Contractor's design for the excavation support system and dewatering system are unable to control the water inflows, the Contractor shall apply additional methods to control groundwater inflows at no additional cost to the Owner.

C. Launch and receiving shaft subgrade shall be kept continuously free from ground and surface waters during tunneling operations.

D. Limit over excavation to within +10% of calculated excavation volume. Over excavation volumes greater than +10% that would potentially allow excessive settlements shall be reported to the Engineer.

E. Should settlement or displacement be detected exceeding the threshold values as specified in Section 02495, notify the Engineer and applicable agency immediately and act to maintain safe conditions and prevent damage.

F. Water discharge from surface flow diversion or miscellaneous pumping shall be directed into approved receiving basins in accordance with all applicable regulatory requirements.

3.02 DAILY ACTIVITY LOG

A. Maintain a daily activity log during jacking operations for casing and submit to the Engineer for record purposes on a daily basis including:

1. Start and finish time of casing pipe advancement.

2. Total length of casing pipe installed.

3. Horizontal and vertical alignment deviation at not greater than 1 foot intervals or period not exceeding 5 minutes, whichever is most frequent.

4. Maximum jacking force exerted during installation of each casing pipe section including forces required to re-initiate jacking following periods of system shutdown.

5. General description for each discernible ground condition mined.

6. Settlement monitoring readings

7. Monitoring well readings

8. Vibration monitoring

3.03 PREPARATION

A. Complete the preconstruction survey and installation and the initial readout for geotechnical instrumentation as specified in Section 02495 prior to commencing tunnel excavation.

B. Tunneling operations shall be performed in a manner and precautions shall be taken to avoid interruptions which might cause the pipe to "freeze" in place.

C. Maintain clean working conditions inside jacking operation area and remove spoil, debris, equipment, and other material not required for operations.

D. For construction below all waterways, railways, roadways and all utilities, perform installation to prevent interference or disruption with normal operation of these facilities.

E. During construction, maintain access to private and commercial properties at all times, unless approval from property owner has been obtained.

F. Provide power generation equipment and any other equipment operating on or with fuel or lubrication oils with suitable barriers and safeguards to ensure no loss of oil to drains or waterways or to contaminate ground.

3.04 LAUNCH AND RECEVING SHAFT CONSTRUCTION

A. Excavate launch and receiving shafts and provide excavation supports as required and as specified in Section 02311 Excavation Support and Protection.

B. No trench boxes shall be used for excavation support of the launch and receiving shafts. Excavation support for the shafts shall extend a sufficient depth below the invert of the pipe to resist all overburden pressures and hydrostatic pressure outside the shafts. The excavation support systems shall meet the minimum requirements shown on the Contract Drawings.

C. Adequate safety measures shall be provided to prevent pedestrian access to the excavation area and fall protection shall be provided. Excavation support shall extend at least 42 inches above existing grade. Alternatively, provide 42-inch high fence, meeting the OSHA requirements around all excavations.

D. Furnish and install a level concrete slab at the bottom of the launch shaft. Steel rails or beams shall be embedded in the concrete slab for placement and alignment of each piece of casing pipe or carrier pipe during installation operations.

E. Furnish, install and remove, to the extent required, thrust blocks or such other provisions as may be required in driving the casing pipe or carrier pipe forward.

F. All shafts will be backfilled with CSLM upon completion of the tunneling work as shown on the contract drawings.

G. Shoring within the zone of influence of structures utilities or roadways shall be cutoff 5 feet from the surface and left in place. The zone of influence shall be any area below a slope of 1.5 horizontal by 1 vertical starting at the bottom of the footing, paving or utility invert.

3.05 TOLERANCES

A. Maintain proper alignment and elevation of the pipe consistently throughout the microtunneling. Tolerances for the installation of the casing pipe shall be as follows:

1. Line Tolerance: +/-1 inch for every 200 feet of tunnel length.

2. Grade Tolerance: +/-1 inch for every 200 feet of tunnel length.

3. Water shall be free draining between any two points at the pipe invert. No reverse grades will be allowed.

3.06 TUNNELING

A. Perform tunneling operations in a manner that will minimize loss of ground and minimize settlement of the ground surface and roadway above and adjacent to the tunnel within the limits defined in section 02495 Geotechnical Instrumentation. The shield shall be steered to maintain line and grade within the tolerance specified. This shall be achieved by continuously monitoring line and grade, and making the steering adjustments required during the operation.

B. Tunneling shall be performed in a manner to prevent voids from developing outside the casing and/or the carrier pipe.

1. Limit annular space, between excavated material and outside diameter of casing pipe, to maximum of 0.5-inch.

C. Casing pipes shall be jacked into place without damaging the pipe. In the event a section of pipe is damaged during the jacking operation, the pipe shall be jacked through to the receiving shaft and removed. Other methods of repairing the damaged pipe may be used, subject to approval by the Engineer. Repair any damage to the interior lining in accordance with lining manufacturer's written recommendations. Provide a pipe lubrication system as necessary; to inject bentonite and/or polymer as required minimizing pipe friction and jacking forces.

D. As a minimum, the thrust force, rate of advance, distance along the drive, deviation from line and grade, and steering jack adjustments shall be monitored and recorded at 1-foot intervals for each pipe installed.

E. The thrust block shall be properly designed and constructed to provide the required resistance to the forces developed by the proposed main jacks. Construct the thrust block normal to the pipe alignment. The thrust block shall be designed to support the maximum obtainable jacking pressure developed by the main jacking system.

F. Restrict the excavation of the materials to the least clearance necessary to prevent binding in order to avoid loss of ground and consequent settlement or possible damage to overlying structures. Control the advance rate and the volume of material excavated to avoid over-excavation and heave.

G. Properly dispose of all excavated materials away from the construction site on a daily basis. No stockpiling shall be permitted at the launch shaft site. Slurry shall be pumped into tanker trucks and disposed of at acceptable facilities in accordance with current state regulations for disposal of these materials. Only use the disposal sites identified in the submittals for muck and slurry disposal.

H. The Contractor shall be responsible for damages resulting from subsidence, collapsed tunnels, or ground losses into the tunnel and for the refilling of voids resulting there from with grout. Where such ground losses are so severe that they result in damage to underground or surface pavement, existing utilities, structures, railways or private property, the Contractor shall be solely responsible for remedying such damage. Where the filling of voids cannot be effectively carried out from below, the Engineer reserves the right to order the Contractor, at no additional cost to the Owner, to make openings from the surface for the purpose of backfilling the voids. If, in the judgment of the Engineer, a portion of the tunnel requires reinforcing because of such collapse, the Engineer may direct the Contractor to furnish and place such reinforcement at no additional cost to the Owner. Reinforcement may also be directed when the stability of the soil adjacent to the tunnel has been affected by the loss of ground.

I. The Contractor shall be responsible for all effects on road traffic resulting from such ground loss, including all costs and all coordination with and meeting traffic control requirements of the applicable governing agency, and the required traffic control, permit acquisition, flagger fees, fines, etc.

J. Maximum allowable deflection of the inside diameter of the tunnel in any direction from a true circle shall be 1.0 percent of the inside diameter. Deflection shall be measured at not more than 50 foot intervals.

K. Furnish and install, and later remove to the extent required, thrust blocks or other provisions for backing up the jacks employed in driving the pipe forward.

L. Immediately following the tunneling operation, pressure grout the jacked section to fill a minimum of 99% of the theoretical void space existing outside of the pipe. Grouting shall be from the interior of the pipe through the grouting holes.

3.07 CONTROL OF LINE AND GRADE

A. Establish benchmarks and survey control points and maintain benchmarks and survey control point during construction.

B. When satisfied that all benchmarks are correct, use these benchmarks to furnish and maintain all reference lines and grades for the tunnel and sewer construction. Use these lines and grades to establish the exact location of the pipe using a laser guidance system on the tunneling machine.

C. Submit to the Engineer copies of field notes used to establish all lines and grades and provide 24 hours advance notice to allow the Engineer to check laser set up prior to beginning microtunneling. The Contractor shall be fully responsible for the accuracy of his work and corrections, if required.

D. Use an acceptable laser system to monitor line and grade continuously during pipe jacking operations. Laser supports should be independent of working slab, jacking frame, and thrust block to avoid movement of the laser during jacking. Stop operations and reset laser immediately if movement of laser occurs during the Work. Monitor line and grade continuously during pipe jacking operations and record deviation with respect to design line and grade at least once per foot and submit records to the Engineer at least daily or as requested. Control line and grade of the pipe to within the specified tolerances.

E. When the excavation is off line or grade, make the necessary corrections, and return to the plan alignment at a rate of not more than 1 inch per 25 feet.

F. If the pipe installation exceeds the specified tolerances, correct the installation, including, if necessary, redesign of the interceptor or structures. All corrective work shall be performed at no additional cost to the Owner and is subject to the approval of the Engineer.

G. The line and grade may be checked by the Owner. Provide access for the Owner’s Representatives to check the line and grade as requested by the Owner. Said checking shall not substitute for the Contractor's own line and grade control responsibilities.

3.08 REMOVAL OF OBSTRUCTION DURING TUNNELING

A. Obstructions shall be defined as man-made objects such as concrete, wood, railroad ties, wood sheeting and various steel obstructions which satisfy both conditions stated below:

1. Objects which are 4 cubic feet in volume or larger, and

2. Objects which completely stop the forward progress of the tunneling operation when jacking by the full effort and power available from the Contractor's equipment.

B. Boulders are defined in the GBR.

C. Where encountered, the Contractor shall take appropriate measures to remove or break bedrock, relic rock and boulders by a suitable method approved by the Engineer.

D. The Contractor shall notify the Engineer immediately upon encountering an obstruction or boulder which stops forward progress of the Work. The Engineer shall verify that forward progress of the Work has stopped for more than 30 minutes and authorize the Contractor to commence activities to remove the obstruction or boulder.

E. No compensation will be considered or allowed for over-breakage of obstruction beyond a circumferential arc 6 inches outside of the outside diameter of the pipe. Where such circumferential removal leaves or creates a "void" over or around the pipe, the Contractor shall be required to inject or place concrete or other suitable substance to "structurally" fill the void to the satisfaction of the Engineer.

F. The Contractor is responsible to properly select the type of tunneling equipment and type of cutting suitable for the mixed face conditions and the removal, cutting or crushing of cobbles and boulders anticipated to occur during tunneling.

G. The Contractor is responsible to properly select the type of tunneling equipment suitable for maintenance of line and grade during the mixed face conditions anticipated to be present along the alignment.

3.09 SITE AND WORK SAFTEY

A. Comply with applicable regulations of Federal Government, OSHA 29CFR 1926, and applicable criteria of ANSI A10.16-1995 (R2001), "Safety Requirements for Tunnels, Shafts, and Caissons".

B. Arrange and conduct a pre-job safety conference and inform the Engineer of the time and place of the conference at least 1 week in advance.

C. The Contractor's site safety representative shall prepare a code of safe practices and an emergency plan in accordance with OSHA requirements. Provide the Engineer with a copy of each prior to starting pipe jacking. Hold safety meetings and provide safety instruction for new employees as required by OSHA.

D. Adequate safety measures shall be provided to prevent pedestrian access to the excavation area and adequate fall protection shall be provided at all shaft locations.

3.10 TEMPORARY VENTILATION, LIGHTING AND COMMUNICATION SYSTEMS

A. Furnish and operate (when personnel are underground) temporary ventilation, lighting, air monitoring and communication systems conforming to the requirements of OSHA.

B. Operate and maintain a ventilation system that provides a sufficient supply of fresh air and maintains an atmosphere free of toxic or flammable gasses in all underground work areas.

3.11 CASING GROUTING

A. Grout shall be forced under pressure into the grouting connections. Grouting shall be performed from the interior of the tunnel. Grouting shall be started in the lowest connections and shall proceed until grout begins to flow from upper connections. The void shall be completely filled.

B. Apparatus for mixing and placing grout shall be capable of mixing effectively and stirring the grout and then forcing it into the grout connections in a continuous, uninterrupted flow.

C. After grouting is complete, pressure shall be maintained by means of stopcocks or other suitable device until the grout has set sufficiently in the judgment of the Engineer, or for a minimum of 24 hours, whichever is longer. After the grout is set, grout holes shall be completely filled and finished neatly without evidence of voids or projections.

3.12 CARRIER PIPELINE INSTALLATION IN TUNNEL

A. After tunnel casing installation is complete and found acceptable by the Engineer, the Contractor shall prepare for installation of the carrier pipe by installing rails or other methods acceptable to the Engineer, to control the line and grade of the pipe during installation. All rails shall be embedded in concrete in the invert to the specified grade of the pipeline. Two steel channel rails of suitable size and shape shall be positioned accurately by a welded steel support system and then partially embedded in the concrete to support the pipe. Rails shall have top flanges at least 1.5 inches wide and shall weigh at least 5.0 lbs per foot. Rails shall be lubricated to minimize sliding friction. The rails shall in no way be connected to or touching the tunnel casing.

B. The pipes shall be supported securely on casing spacers in such a manner that the pipe is supported on each end and at the 1/3 point along each pipe segment by the casing spacers. The casing spacers shall remain in place and shall be securely fastened to the pipe by banding. Each segment of pipe shall be pulled or winched through the tunnel supported on the casing spacers Under no conditions will pipe transport equipment that places any load on the interior of the preceding pipe section be allowed, nor will sliding the pipe directly on casing be allowed.

C. Each pipe segment shall be supported against the tunnel to prevent displacement during grouting as specified herein.

D. Each gasketed air-testable pipe joint shall be air tested immediately after installation per the appropriate pipe specification. Block pipe as necessary to prevent joint separation during testing and reduce pressure to 2.0 psi. There shall be no exceptions to this requirement. No gasketed air-testable pipe will be paid for until it has been successfully air-tested.

E. After the carrier pipe has been installed in the tunnel, the annular space shall be backfill as specified herein.

3.13 FILLING OF ANNULAR SPACE

A. Contractor shall arrange and route utilities to provide ready and available services during grout backfill placement.

B. The Engineer shall be informed at least 24 hours in advance of the times when placement of annular grout backfill material is scheduled.

C. Backfill in the mixer and holding tanks shall be continuously agitated. Grout backfill that is not injected into the hole within 2 hours after mixing shall be removed from the mixer, holding tank and supply line and all equipment shall be washed.

D. Grout backfill shall be stored in accordance with manufacturer's recommendations. Grout backfill shall be maintained at temperatures above 50 degrees F until injected. The temperature of mixing water shall range between 50 degrees F to 100 degrees F when added to the grout mixer.

E. Bulkheads shall be constructed at the ends of tunnel to be backfilled.

F. Bulkheads shall be constructed so that the annular space will be completely backfilled.

G. Bulkheads shall incorporate a minimum 1-inch drain pipe in the invert and crown of the tunnel to facilitate drainage of water and air during backfilling. The pipes shall be securely capped and plugged once annular grout backfill material begins to flow from the drain line.

H. Contractor shall conform to the requirements of accepted submittals and the manufacturer's recommendations.

I. All grout backfill shall be mechanically mixed to produce a uniform distribution of the materials with a suitable consistency and the specified limiting requirements. Excessive mixing shall be avoided in order to reduce the possibility of changes in unit weight and consistency.

J. For continuous mixing operation provisions shall be made reasonably uniform and continuous rate of addition of all mix components at appropriate positions in the mixing machine, and in the correct ratio, to assure uniformity and the specified limiting requirements at the point of placement.

K. Alternative method for batching and mixing grout backfill may be considered but shall require approval from the Engineer.

L. Contractor shall verify that location where grout backfill is to be placed are clean and free of standing or running water.

M. Prior to backfilling, each pipe joint shall be air tested immediately after installation per the appropriate pipe specification. Block pipe as necessary to prevent joint separation during testing.

There shall be no exceptions to this requirement. No pipe will be paid for until it has been successfully air tested.

N. Access manholes shall be installed and connections to the carrier pipes shall be completed prior to backfilling around the carrier pipes.

O. All void spaces outside of the carrier pipe shall be completely filled with annular grout backfill. Grout backfill material shall be forced into all irregularities around the tunnel to completely fill the tunnel annulus with structural grout or LDCC to the maximum extent possible. Vent pipes shall be placed at high areas of the crown to provide for venting of entrapped air and water.

P. Methods for verifying complete filling the annular space between the pipe and the surrounding ground or initial support shall be acceptable to the Engineer. No standing water shall be allowed where grout backfill is placed.

Q. Grout backfill shall be placed though grout piping installed in the crown of the tunnel. Grout placement location shall be spaced no further than 50 feet apart. The grout piping and grout placement locations shall account for the access manholes along the tunnel and allow for complete grout placement all around the access manholes.

R. The limits of each grout backfill placement stage shall be predetermined by the size and capacity of the batching equipment and the initial set time of the proposed grout backfill. Under no circumstance shall placement continue at an injection point longer than that period on time for the mix to take initial set. A stage of lift cannot be installed on another lift until a proper set has been obtained.

S. Methods for preventing damage to pipe joints due to thermal expansion of the pipe during backfill grouting shall be acceptable to the Engineer. The Contractor is responsible for the repair of any pipe damage caused by thermal expansion during grouting.

T. Contractor shall limit pressure on the annular space to prevent damage or distortion to the carrier pipe or initial support.

U. The pipe shall be solidly supported from the tunnel wall in four quadrants (bottom, top and sides) using blocking secured sufficiently to prevent pipe movement during grouting or pressure testing. Bracing shall be located within 2 feet of each pipe joint and not farther than 20 feet apart. Adjust the elevation and alignment of each pipe with wood shims if necessary before blocking. Pipe alignment tolerance shall be as specified for general pipe installation. Contractor shall not remove bracing and supports for carrier pipe until grout backfill has achieved initial set as determined by ASTM C403.

V. The pipe in the shafts shall be solidly supported from the shaft wall using bracing capable of supporting the weight of the pipe and secured sufficiently to prevent pipe movement during grouting or pressure testing. Bracing shall be located within 2 feet of each pipe joint and not farther than 20 feet apart. Pipe joints shall be adequately restrained to resist pipe pullout. Pipe alignment tolerance shall be as specified for general pipe installation. Contractor shall not remove bracing and supports for carrier pipe until grout backfill has achieved initial set as determined by ASTM C403.

W. Volume of grout backfill injected shall be calculated on an indirect basis and compared with the anticipated volume per foot of pipe backfilled.

X. A minimum of two (2) sets of four (4) test cylinders (3 inches by 6 inches) will be sampled for each shift when grout backfill is placed. Additional test samples shall be made if deemed necessary by the Engineer. The test samples shall be made from the grout backfill as it is being placed and shall, as nearly as possible, represent the material being applied.

Y. The method of testing the test samples shall be as follows:

1. Test cylinders will be made in the field, stored in the lab and tested in accordance with ASTM C 495.

2. Compressive strength test will be judged acceptable if the average of two consecutive test equals or exceeds the specified strength and no individual test is below the specified strength by more than 20 percent.

3. Each set of compression test cylinders will be marked or tagged with the date and time of day the cylinders were made, the location in the work where the backfill represented by the cylinders was placed, batch number, and unit weight (wet density).

4. Cylinders will be tested at an age of 7, 28, and 56 days, and one cylinder shall remain held in reserve.

3.14 RESTORATION

A. All areas disturbed by construction shall be restored in accordance with Sections 02575 Restoration of Surfaces; 02930 Loaming and Hydroseeding; and 02901 Miscellaneous Work and Cleanup, to existing or better condition and maintained until accepted by the Engineer.

END OF SECTION 02325

GEOTECHNICAL BASELINE REPORT

Beaver Creek Clean River Project

Albany Water Board (AWB),
Albany, New York

October 2020

Geotechnical Baseline Report

For

BEAVER CREEK CLEAN RIVER PROJECT

Albany Water Board (AWB), Albany, New York

October 2020

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Acronyms

ACWPD	Albany County Water Purification District
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Materials
ATL	Atlantic Testing Laboratories
AWB	Albany Water Board
bgs	below ground surface
bl/ft	Blows per foot
CDM Smith	Camp Dresser McKee & Smith
DSC	Differing Site Conditions
El.	Elevation
GBR	Geotechnical Baseline Report
GDR	Geotechnical Data Report
HQ	HQ single core barrel
JBL	Jersey Boring & Drilling Co., Inc.
MTBM	Microtunnel Boring Machine
NAD83	North American Datum 1983
NAVD88	North American Vertical Datum 1988
Project	Beaver Creek Clean River Project
psi	pounds per square inch
RMR	Rock Mass Rating
RQD	Rock Quality Designation
SPT	Standard Penetration Tests
Sta.	Station
UCS	Uniaxial Compressive Strength
USCS	Unified Soil Classification System
WOH	Weigh of Hammer

Section 1

Introduction

1.1 Introduction

This Geotechnical Baseline Report (GBR) has been prepared by Camp Dresser McKee & Smith (CDM Smith) under contract to Albany Water Board (AWB), for the proposed 72-inch sewer line running between the proposed diversion structure and the screening/disinfection facility and the 30-inch sewer discharge line running between the disinfection facility and the precast manhole structure #6; both are part of the Beaver Creek Clean River Project (Project). The project owner is the Albany Water Board. These sections of the Project are designed by CDM Smith. The term "Engineer" and CDM Smith are equivalent in this report.

This GBR is specifically related to the construction of tunnels and open cut segments required to install the 72-inch diameter and 30-inch diameter pipeline segments of the project identified herein, and the associated vertical access shafts, as shown on the Contract Drawings. The 72-inch sewer line and the 30-inch inter-connection line will be procured under separate contracts. Sections specifically related to the 30-inch inter-connection line are not applicable to the 72-inch sewer line; sections specifically related to the 72-inch sewer line are not applicable to the 30-inch inter-connection line. The tunnel for the 72-inch diameter pipeline will be approximately 528 feet in length. The tunnel for 30-inch diameter pipeline segment consist of five (5) individual tunnel runs ranging in length from approximately 250 feet to 700 feet with a combined length of approximately 2,280 feet. The remaining, approximately, 365 feet will be constructed by open cut.

This GBR covers the tunnel alignment defined for the 72-inch sewer pipe from Sta. 0+00 to Sta. 5+29.85. This GBR also covers the micro-tunnel and open cut alignment defined for the 30-inch inter-connection pipe from Sta. 0+00 to Sta. 26+96 (approx.). Although stationing for each tunnel starts at 0+00, the alignment is distinct; at no point do the stationing coincide.

1.2 Project Description

The Project is intended to screen and disinfect combined sewage from the Beaver Creek sewer in the City of Albany that is discharged from Outfall No. 016, or commonly referred to as Big C. The Project consists of constructing a new floatable control and disinfection facility, a new diversion structure, a new 72-inch diameter, 528 feet long sewer line, a new 30-inch diameter, 2,827 feet long wastewater inter-connection line, and other associated structures. The 72-inch diameter sewer line will consist of a 72-inch carrier pipe installed within an estimated 9-foot wide by 9-foot high horseshoe shaped tunnel segment excavated from a working shaft near the disinfection facility to a bulkhead location near Delaware Avenue and approximately 10 feet of tunnel from the working shaft toward the screening facility. This section will be bulkheaded as well. This tunnel segment will be referred to in this GBR as the 72-inch tunnel segment. A second tunnel segment and an open cut segment will be required for the construction of a new wastewater system 30-inch inter-connection line.

This second tunnel segment and the open cut segment will be referred to as the 30-inch tunnel and 30-inch open cut respectively. The purpose of the 30-inch line is to convey wastewater flows and screenings from the new facility to Third Avenue, and ultimately the Albany County Water Purification District (ACWPD) Hudson River Interceptor in the vicinity of South Pearl Street and Gansevoort Street.

1.3 Project Datum

The horizontal project datum is the North American Datum of 1983 (NAD83), in feet. The elevations (El.) noted herein are in feet and referenced to the North American Vertical Datum of 1988 (NAVD88).

1.4 Purpose and Organization of Geotechnical Reports

The geotechnical Contract Documents for this project are comprised of the Geotechnical Data Report (GDR) and the GBR. The description of these reports follows:

Geotechnical Data Report (GDR). The GDR presents a description of the field exploration and testing programs conducted for this project, provides a summary of the methods used for the explorations and testing procedures, provides an overview of the geologic setting and general site conditions, and contains the geotechnical data and information that has been obtained during the design.

Geotechnical Baseline Report (GBR). The primary purpose of the GBR, as defined by the American Society of Civil Engineers (ASCE) suggested guidelines (provide reference here), is to present contractual statements describing the geotechnical conditions anticipated (and to be assumed by Contractors) to be encountered during underground construction. The contractual statements are referred to as baselines or baselines statements. GBR established baselines for the subsurface conditions are to be used by Contractors in preparing their bids and subsequently by the selected Contractor as the basis for any changed conditions claims for the underground work and by the Owner in evaluating differing site condition claims.

1.5 Hierarchy of Contract Documents

This GBR establishes baseline values for bidding and will be used to evaluate any Differing Site Conditions (DSC) claims during the work for tunneling, excavating and supporting the ground for this crossing. The GBR is binding upon the AWB and the Contractor. In the case of conflicts or inconsistencies among the Drawings and Specifications, the GBR and the GDR, precedence shall be given in the following order:

1. General Conditions,
2. Drawings,
3. Specifications,
4. Geotechnical Baseline Report, and
5. Geotechnical Data Report.

1.6 Organization of GBR

An outline of this GBR is presented below:

- Section 1 – Introduction: provides the project background, a project description, describes the purpose and scope, and limitations of this document.
- Section 2 – Geologic Setting and Subsurface Conditions: summarizes an overview of the geologic settings and subsurface conditions. This section also presents the contract interpretation of subsurface soil, and groundwater conditions that underlie the project.
- Section 3 – Baseline Values: provide uniform basis for all bidders in preparation of their bids, this section provides: 1) baseline values for geotechnical parameters, 2) ground conditions/behavior, and 3) groundwater conditions/inflows to be encountered during construction. This section also Identifies important geotechnical considerations and constraints which need to be addressed by the Contractor during construction.
- Section 4 – Construction Considerations: Construction considerations are not baseline statements and will not be accepted as the basis for any changed conditions claims. The intent of this section is to provide bidders with the Engineer's opinion of construction methods. This section discusses construction constraints and flexibilities for the proposed tunnel and open cut segments, the launch shaft and the receiving shaft including construction sequencing, excavation methods, and rationale the engineer assumed in preparing the other contract documents.
- Section 5 – References: includes relevant references.

1.7 Limitations of Use

The Contractor is responsible to read and consider the GBR and all other Contract Documents in their entirety in developing their project approach, construction means and methods, equipment selection, and in planning and bidding all other elements of the work. Bidders should have on staff or retain the services from a qualified engineering geologist/geotechnical tunneling engineer to help evaluate and interpret this document and related geologic/geotechnical documents.

In establishing these baselines, the Engineer considered available data and past construction experience in similar ground conditions. Although actual conditions encountered in the field are expected to be within the range of conditions discussed herein, there is no warranty that the baseline conditions will be encountered. Ground behavior will be influenced by the construction sequence and methods employed by the Contractor, as well as the Contractor’s equipment and workmanship. It has been assumed that the level of workmanship will be consistent with what can be reasonably expected from an experienced and qualified Contractor.

Section 2

Geologic Setting and Subsurface Conditions

This section presents an overview of the regional geologic conditions and the subsurface conditions along the 72-inch dimeter tunnel segment. The project area geology, subsurface conditions, and groundwater conditions discussed below are based on information obtained from local and regional geologic maps and reports, and the results of the field exploration and laboratory testing programs.

2.1 Regional Geology

The project site lies within the Hudson-Mohawk Lowlands, a physiographic feature that extends nearly the entire north-south length of eastern New York bounded everywhere by uplands except a few ridges in the south, narrowing to the north. The surficial topography is the result of multiple glacial advances and retreats, within which glacial Lake Albany was sited and includes the Mohawk, Black, and Hudson Rivers. The geology is dominated by Ordovician sedimentary rock including soft shales, limestone, sandstone, in addition to mélange (both exotic and non-exotic) from the progressive deformation of flysch (a sedimentary deposit consisting of thinly bedded shale or claystone with repetitive coarser grained sedimentary rock) as an accretionary wedge that occurred along the North American continental margin approximately 440 to 480 million years ago.

2.2 Surficial Geology

The soil cover along the proposed alignment consists of alluvial, and glacial deposits overlying the bedrock. The glacial deposits consist of clays, silts, and sands, commonly varved, that thicken to the east. Within the western portion of the project the soils are deep to shallow fill consisting of predominantly silt and clay which are underlain by silty clay and highly weathered moderately dipping shale. Soils along the eastern portion of the project consisted of a shallow veneer of fill underlain by fine-grained (periodically varved) glacio-lacustrine soils. At some locations dense, dry, coarse grained soils were and hard clay were also encountered just above bedrock. The uppermost bedrock unit in project area consists of moderately dipping shale of the Waterford Flysch Zone.

2.3 Site Exploration

Seventeen (17) test borings (B-1 through B-17) were drilled from March 25 to May 17, 2019 by Jersey Boring & Drilling Co., Inc. (JBD). Boring P-1 through P-7 were drilled between August 31 and September 4, 2020. Boring Locations are shown on **Figure 2-1**.

Atlantic Testing Laboratories (ATL), based out of Canton, New York drilled the borings B-1 through B-17 using a Geoprobe 7822 drill rig. CHA drilled borings P-1 through P-7 using a Geoprobe drill rig. Borings were advanced using rotary wash methods with 3-inch or 4-inch casing to bedrock. The rotary wash method consists of drilling using a tricone roller bit and

GEOTECHNICAL BORING SCHEDULE

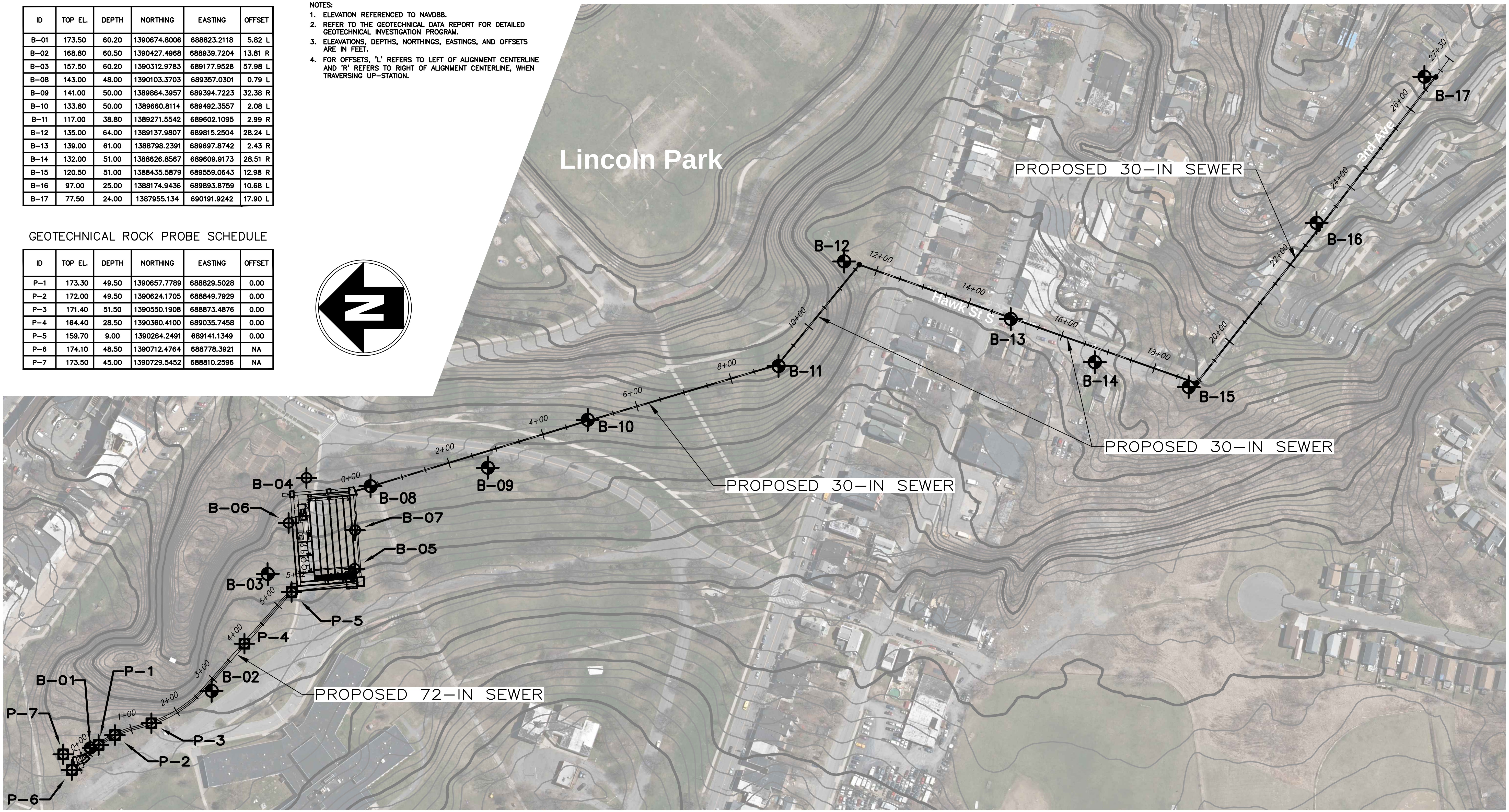
ID	TOP EL.	DEPTH	NORTHING	EASTING	OFFSET
B-01	173.50	60.20	1390674.8006	688823.2118	5.82 L
B-02	168.80	60.50	1390427.4968	688939.7204	13.81 R
B-03	157.50	60.20	1390312.9783	689177.9528	57.98 L
B-08	143.00	48.00	1390103.3703	689357.0301	0.79 L
B-09	141.00	50.00	1389864.3957	689394.7223	32.38 R
B-10	133.80	50.00	1389660.8114	689492.3557	2.08 L
B-11	117.00	38.80	1389271.5542	689602.1095	2.99 R
B-12	135.00	64.00	1389137.9807	689815.2504	28.24 L
B-13	139.00	61.00	1388798.2391	689697.8742	2.43 R
B-14	132.00	51.00	1388626.8567	689609.9173	28.51 R
B-15	120.50	51.00	1388435.5879	689559.0643	12.98 R
B-16	97.00	25.00	1388174.9436	689893.8759	10.68 L
B-17	77.50	24.00	1387955.134	690191.9242	17.90 L

GEOTECHNICAL ROCK PROBE SCHEDULE

ID	TOP EL.	DEPTH	NORTHING	EASTING	OFFSET
P-1	173.30	49.50	1390657.7789	688829.5028	0.00
P-2	172.00	49.50	1390624.1705	688849.7929	0.00
P-3	171.40	51.50	1390550.1908	688873.4876	0.00
P-4	164.40	28.50	1390360.4100	689035.7458	0.00
P-5	159.70	9.00	1390264.2491	689141.1349	0.00
P-6	174.10	48.50	1390712.4764	688778.3921	NA
P-7	173.50	45.00	1390729.5452	688810.2596	NA

NOTES:

1. ELEVATION REFERENCED TO NAVD88.
2. REFER TO THE GEOTECHNICAL DATA REPORT FOR DETAILED GEOTECHNICAL INVESTIGATION PROGRAM.
3. ELEAVATIONS, DEPTHS, NORTHINGS, EASTINGS, AND OFFSETS ARE IN FEET.
4. FOR OFFSETS, 'L' REFERS TO LEFT OF ALIGNMENT CENTERLINE AND 'R' REFERS TO RIGHT OF ALIGNMENT CENTERLINE, WHEN TRAVERSING UP-STATION.



LEGEND

- B-01 DESIGNATED AND APPROXIMATE LOCATION OF TEST BORINGS DRILLED AND LOGGED BY CDM SMITH BETWEEN MARCH 25, 2019 AND MAY 17, 2019.
- B-4 DESIGNATED AND APPROXIMATE LOCATION OF TEST BORINGS DRILLED AND LOGGED BY CHA IN 2019.
- P-1 DESIGNATION AND APPROXIMATE LOCATION OF ROCK PROBES DRILLED AND LOGGED BY CHA IN JULY 2020.

1" = 200'

100 0 200

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BORING LOCATION PLAN
FIGURE 2-1

drilling fluid (recycled water) to wash the soil cutting from the borehole, cool the bit, and to maintain borehole stability. Soil sampling was performed using a split spoon sampler. Standard 5-foot sampling intervals were typically used from the ground surface to bedrock. At borings B-12, B-15, and B-17, continuous soil sampling intervals were used from the ground surface to bedrock, where tunnel shaft are anticipated for construction.

When competent rock was encountered, rock coring was conducted to advance the boring using a HQ single core barrel (HQ) samples were classified in the field and the Rock Quality Designation (RQD) was determined for each coring run. It should be noted that the use of a single core barrel can result in poor recovery and excess core breakage. A more complete description of the drilling methods and exploration locations is provided in the GDR.

2.4 Laboratory Testing

Representative samples of the overburden soil encountered in the explorations were tested at CDM Smith's Chelmsford, Massachusetts laboratory for moisture content (American Society for Testing Materials (ASTM) D2216), grain size distribution (ASTM D422 and ASTM D1140), and Atterberg limits (ASTM D4318). Laboratory test were conducted on representative samples of the rock core obtained from the test borings. Rock tests included uniaxial compressive strength (ASTM D7012), Point Load Index (ASTM D5731), CERCHAR Abrasivity Index (ASTM D7625), X-Ray Diffraction and thin section petrographic analysis. Geotechnical laboratory testing on rock was conducted by GeoTesting Express of Acton, Massachusetts, except for the petrographic analysis and X-Ray Diffraction, which were conducted by Spectrum Petrographics of Vancouver, Washington and K-T GeoServices Inc of Gunnison, Colorado, respectively. A complete description of the testing and results is provided in the GDR.

Geotechnical laboratory testing was performed on selected soil and rock samples. The laboratory testing program included index test, strength tests, and minerology tests to classify soil/rock into similar geologic units and project strata and to measure the engineering properties to support engineering analyses.

The following tests were performed:

Soil Testing:

- Twenty-seven (27) Atterberg Limits,
- Twenty-four (24) Hydrometer and Sieve Analysis,
- Twenty-five (25) moisture content tests, and
- Nineteen (19) triaxial tests on seven (7) undisturbed Shelby Tube samples.

Rock Testing:

- Nine (9) X-ray diffraction analyses. The predominant mineral detected in the test consisted of mixed layer clay minerals which ranged from 42 to 49 percent followed by Quartz which ranged from 32 to 26 percent. Mixed-layer clay minerals are materials in which different kinds of clay mineral layers alternate with each other. Commonly described mixed-layer clays include: illite-vermiculite, illite-smectite, chlorite-vermiculite (corrensite), chlorite-smectite, and kaolinite-smectite.

- Nine (9) petrographic analyses. The results identified that clay minerals were predominant in the sample.

- Three (3) Uniaxial Compressive strength tests, Because of the intensely fracture nature of the rock relatively few samples large enough for Unconfined Compressive Strength (UCS) test were obtained. The UCS of the claystone shale ranges from 121 to 1,713 pounds per square inch (psi) with an average value of 1,013 psi for the all three test samples that were tested.

- Eight (8) Brazilian splitting tensile strength tests.

- Nineteen (19) axial point load tests. The point load index (IS50) ranged from 15 to 175 psi in axial testing orientation.

- Eleven (11) Cerchar Abrasivity index tests. The results of these tests ranged from 0.61 to 1.01 with an average of 0.77.

- Four (4) Drillability Index Suite tests. The test results ranges are as show in **Table 2-1**.

- Nine (9) Slake Durability tests. Slake durability index of the tested samples ranged from 96.6 to 98.8.

Table 2-1 Drillibility Test Results

Test Result	Result Range
Drilling Rate Index	70 – 81
Bit Wear Index	8 – 15
Cutter Life Index	63.3 – 116.6

2.5 Subsurface Conditions

The subsurface conditions encountered at the proposed tunnel segments consisted of fill, clay, Sand – Silt, and hard clay with sand and gravel overlying weathered shale and shale.

2.5.1 Fill

Fill was encountered at all three exploration locations. The fill layer thickness ranged from approximately 7 to 25 feet at the exploration locations and consisted of brown, SILT and CLAY with trace sand and gravel and various amounts of debris and organic matter.

2.5.2 Clay

The clay layer was encountered at boring locations B-1, B-2, B-10 through B-17, and its thickness generally ranged between 5 and 14 feet. This layer typically consisted of tan to reddish brown, silty clay with various amount of sand and gravel, and occasionally interbedded layers of fine sand. Consistency of the material ranged from very soft to stiff. Very soft to soft soils were typically encountered near the top of groundwater table with higher strength soil layers both above and below the very soft layers. Standard Penetration Tests (SPT) N-values in this layer ranged from weight of hammer (WOH) to 14+ blows per foot (bl/ft) with an average of about 7 bl/ft at the exploration locations. The Unified Soil Classification System (USCS) symbol of the soils within this layer include CL (Low Plastic Clay), SM (Silty Sand) and CH (High Plastic Clay).

2.5.3 Very Stiff to Hard Clay with Sand and Gravel

The Very Stiff to Hard Clay with Sand and Gravel was encountered at boring locations B-8 and B-9, and the thickness generally ranged between 1 and 7 feet. This layer typically consisted of very stiff to hard gray, silty clay with various amount of sand and gravel, and occasionally interbedded layers of fine sand. SPT N-values in this layer ranged from 41 bl/ft to 69+ bl/ft with an average of about 52 bl/ft at the exploration locations. The USCS classification symbol of the soils within this layer include CL (Low Plastic Clay), SC (Clayey Sand) and CH (High Plastic Clay).

2.5.4 Sand - Silt

The sand layer was encountered at boring locations B-10, B-11, B-13, B-14, and B-15, and the thickness generally ranged between 5 and 8 feet. This layer typically consisted of very dense, olive brown to gray, sand with occasionally interbedded thin layers of silt and clay. SPT N-values in this layer ranged from 29 bl/ft to 67+ bl/ft with an average of about 48 bl/ft at the exploration locations. The USCS classification symbol of the soils within this layer include SP (Poorly Graded Sand), GC (Clayey Gravel), and SM (Silty Sand).

2.5.5 Weathered Shale

The boundary between soil and rock is not sharply defined. This transitional zone for this project has been characterized as “Weathered Shale”. Weathered shale is found overlying all the parent shale bedrock units encountered at boring locations B-1 through B-11. Weathered shale is defined, for engineering purposes, as residual material exhibiting Standard Penetration Resistances in excess of 50 bl/ft and rock exhibiting an RQD of less than 50. Because of the transitional nature of the weathering, the profile of the Weathered shale is irregular and erratic, even over short horizontal distances. The Weathered shale layer will have a variable thickness and grades to unweathered rock with depth. RQD values in this layer ranged from 0 to 43 percent with an average of about 20 percent at the exploration locations.

Based on the rock core data RQD, the Q-value for rock mass classification, and the Rock Mass Rating (RMR) were calculated. Q-values ranged from 0.2 (very poor) to 4.1(fair) with an average of 1.7 (poor). RMR values ranged from 14 (very poor) to 31(poor) with an average of 22.3(poor). These values are typical for highly fractured rock.

2.5.6 Shale

Bedrock consisting of dark gray moderately to slightly weathered shale was encountered below approximate El. 114 at the B-1 exploration location, El. 133 at the B-2, and El. 129 at the B-3. The RQD of the shale are anticipated to range from 0 to 100 percent.

Based on the rock core data RQD, the Q-value for rock mass classification, and the RMR were calculated. Q-values ranged from 0.3 (very poor) to 30 (good) with an average of 4.9 (fair). RMR values ranged from 20 (very poor) to 44 (fair) with an average of 29.3 (poor). These values are typical for intensely fractured rock.

2.5.7 Groundwater

Along the open cut segment and along both tunnel segments, the Contractor can anticipate encountering groundwater near the top of the clay stratum or within the fill. The groundwater levels are expected to vary with the season and rainfall intensity within the range indicated. The levels will vary with time, season, temperature, the amount of rainfall, and construction activities in the area, as well as other factors. Therefore, groundwater conditions at the time of construction may be different from those found during the exploration program.

As part of the field geologic investigation effort, the groundwater levels were recorded and documented at all exploration locations. Water levels measured in the explorations do not necessarily represent stabilized groundwater levels. Available information regarding the groundwater levels is presented on the boring logs in the GDR. Permeability of the shale was measured by packer testing in the borings B-2 and B-3 above and within10 feet of the tunnel vertical alignment. The calculated Lugeon values ranged from 0 to 3.78 Lugeons and averaged 0.76 Lugeons.

Section 3

Baseline Statements

3.1 Shafts

The shaft locations are expected to be dominated by medium to high plastic clay (CL-CH) with sand lenses at or near the top of the weathered rock contact. Soil conditions will be firm to squeezing in accordance with the Tunnelman's Ground Classification system as shown in **Table 3-1**. Below the overlying soils the shaft excavation will encounter weathered rock that grades into intensely fractured shale with depth. Anticipated rock mass behavior during shaft excavation and when tunneling operation are ongoing are based on the RMR and the Rock Quality Rating or Q-system that is expected to be poor to very poor. The anticipated top elevations for each of the rock stratum are shown in **Table 3-2**.

3.1.1 72-inch Tunnel Working Shaft

The profile shown on **Figure 3-1** is specific for the 72-inch sewer pipe installed in a 9-feet (approximately) diameter tunnel. A working shaft centered at Sta. 5+08 will be constructed and used for the tunnel excavation.

This shaft will encounter fill and clay with some sand lenses overlying moderately hard to hard weathered and frequently fractured, shale. SPT values in the soil ranged from 7 to 36 blows per foot. RQD values of the upper twelve feet of weathered shale ranges from 0 to 50 percent with an average of 24 percent. Values in the shale below the weathered zone RQD range from 0 percent to 85 percent with an average of 34 percent. Rock conditions are expected to be Poor to Very Poor-Quality Shale. Fracture spacings of less than 0.3 feet are anticipated. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block should be expected.

Drilling for the installation of rock bolts is anticipated to be difficult. Fractured rock is anticipated to bind with the rock drill slowing drilling rates and fractured rock may prevent the insertion of the bolt slowing rock bolt installation or requiring additional drilling.

3.1.2 30-inch Tunnel Shafts

The profile shown on **Figures 3-2 and 3-3** is specific for the 30-inch sewer.

Shaft at Station 0+00

The shaft centered at Sta. 0+00 will be constructed and used for the tunnel and manhole construction. This shaft will encounter fill and Hard Clay with sand and gravel layers overlying moderately hard to hard, weathered shale and frequently fractured, shale. SPT values in the soil ranged from 6 to 69 blows per foot. RQD values of the upper weathered shale ranges from 0 to 29 percent with an average of 15 percent and below this weathered shale zone RQD values range from 12 percent to 100 percent with an average of 42 percent. Fracture spacings of less than 0.3 feet are anticipated. Soils may be slow or fast raveling depending upon degree of overstress. Rock conditions are expected to be Poor to Very Poor-Quality Shale. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded

Table 3-1 Tunnelman's Ground Classification

CLASSIFICATION	BEHAVIOR	TYPICAL SOIL TYPES
Firm	Heading can be advanced without initial support, and final lining can be constructed before ground starts to move.	Loess above water table, hard clay, marl, cemented sand and gravel when not highly overstressed.
Slow Raveling to Fast Raveling	Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed; due to loosening or to overstress and "brittle" fracture (ground separates or breaks along distinct surfaces, as opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes; otherwise, the ground is slow raveling.	Residual soils or sand with small amounts of binder may be fast raveling below the water table, slow raveling above. Stiff fissured clays may be slow or fast raveling depending upon degree of overstress.
Squeezing	Ground squeezes or extrudes plastically into tunnel, without visible fracturing or loss of continuity, and without perceptible increase in water content. Ductile, plastic yield and flow due to overstress.	Ground with low frictional strength. Rate of squeeze depends on degree of overstress. Occurs at shallow to medium depth in clay of very soft to medium consistency. Stiff to hard clay under high cover may move in a combination of raveling at excavation surface and squeezing at depth behind face.
Cohesive Running to Running	Granular materials without cohesion are unstable at a slope greater than their angle of repose (+ 30°-35°). When exposed at steeper slopes, they run like granulated sugar or dune sand until the slope flattens to the angle of repose.	Clean, dry granular materials. Apparent cohesion in moist sand, or weak cementation in any granular soil, may allow the material to stand for a brief period of raveling before it breaks down and runs. Such behavior is cohesive running.
Flowing	A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as from the face, crown, and wall, and can flow for great distances, completely filling the tunnel in some cases.	Below the water table in silt, sand, or gravel without enough clay content to give significant cohesion and plasticity. May also occur in highly sensitive clay when such material is disturbed.
Swelling	Ground absorbs water, increases in volume, and expands slowly into the tunnel.	Highly pre-consolidated clay with plasticity index in excess of about 30, generally containing significant percentages of montmorillonite.

Modified from Terzaghi (1946) by Heuer (1974)

Table 3-2 Top of Rock

	Shaft			
	72-inch Tunnel	30-inch Tunnel		
	Sta. 5+08	Sta. 0+00	Sta. 5+00	Sta. 9+00
Top of Weathered Shale Elevation (ft)	144-152	133-129	108-104	96-92
Top of Shale Elevation (ft)	138-144	123-119	100-96	87-83

block should be expected. For base line purposes the Contractor should expect to encounter boulders and hard drilling within the hard clay that will require special tooling. Driving of sheet piles is not expected to be feasible. With proper drilling tooling the boulders shall be considered incidental to the shaft construction. However, production rates for the installation of shafts support shall expected to be reduced by half within the Hard Clay. Drilling for the installation of rock bolts is anticipated to be difficult. Fractured rock is anticipated to bind with the rock drill slowing drilling rates and fractured rock may prevent the insertion of the bolt slowing rock bolt installation or requiring additional drilling.

Shaft - Manhole Structure #2

The shaft centered at Sta. 5+00 will be constructed and used for the tunnel and manhole construction. This shaft will encounter fill, medium stiff clay and weathered shale overlying moderately hard to hard, frequently fractured, shale. SPT values in the soil ranged from 7 to 37 blows per foot. RQD values of the weathered shale ranges from 0 to 46 percent with an average of 15 percent and below weathered shale zone RQD values range from 48 percent to 84 percent with an average of 36 percent. Fracture spacings of less than 0.3 feet are anticipated. Squeezing to raveling soil conditions should be anticipated. Soil will squeeze or ravel into the excavation. Depending on the moisture content ductile, plastic yield and flow may occur due to overstress. Rock conditions are expected to be Poor to Very Poor-Quality Shale. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block should be expected. Drilling for the installation of rock bolts is anticipated to be difficult. Fractured rock is anticipated to bind with the rock drill slowing drilling rates and fractured rock may prevent the insertion of the bolt slowing rock bolt installation or requiring additional drilling.

Shaft - Manhole Structure #3

The working shaft centered at Sta. 9+00 will be constructed and used for the tunnel and manhole construction. This shaft will encounter fill, medium stiff clay and dense sand and weathered rock overlying moderately hard to hard, frequently fractured, shale. SPT values in the soil ranged from 7 to 37 bl/ft. RQD values of the shale ranges from 0 to 79 percent with an average of 52 percent. Fracture spacings of less than 0.3 feet are anticipated. Squeezing to raveling soil conditions should be anticipated Above the water table soil will squeeze or ravel into the excavation. below the water table ductile, plastic yield and flowing conditions may occur due to overstress. Rock conditions are expected to be Poor to Very Poor-Quality Shale. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block should be expected.

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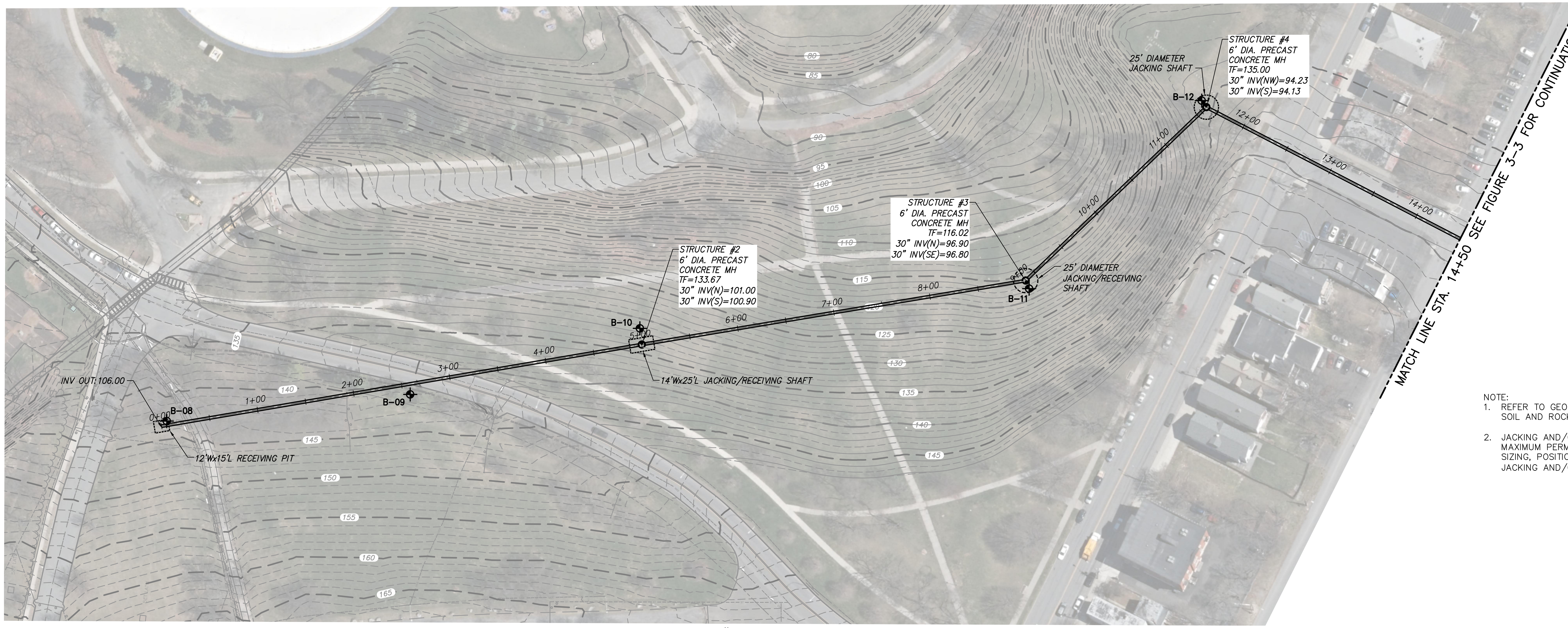
PROPOSED 72-IN PIPELINE PLAN AND PROFILE
FIGURE 3-1



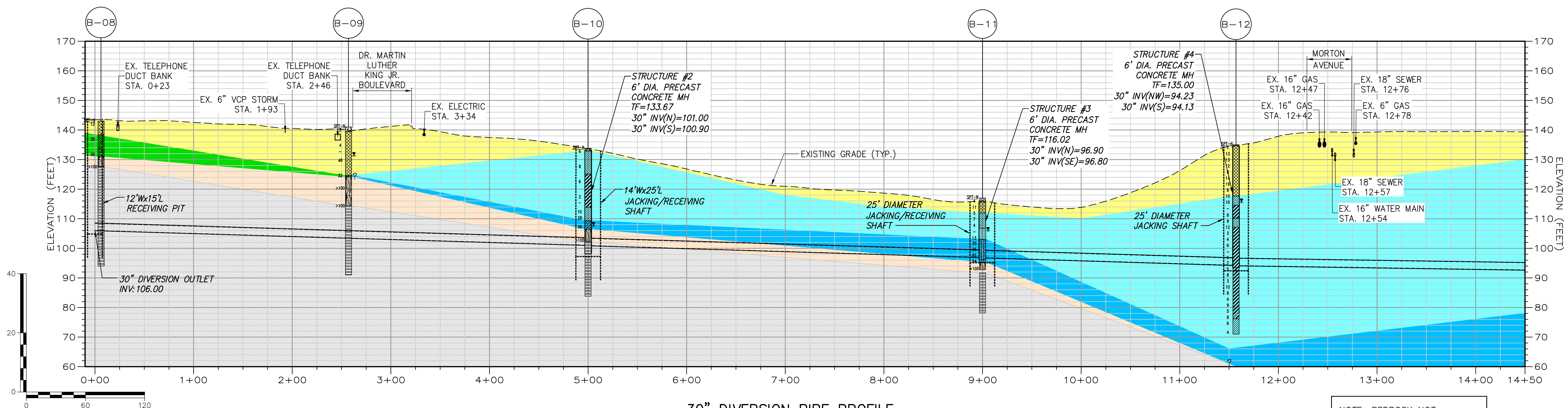
30" DIVERSION PIPE LAYOUT PLAN

SCALE: 1"=60'

0 60 120
Scale in feet

NOTE:

1. REFER TO GEOTECHNICAL DATA REPORT FOR THE DETAILS ON SOIL AND ROCK CLASSIFICATION.
2. JACKING AND/OR RECEIVING SHAFT/PIT SIZES SHOWN AS MAXIMUM PERMITTED. CONTRACTOR SHALL BE RESPONSIBLE FOR SIZING, POSITION, ORIENTING, DESIGNING, AND ETC., THE JACKING AND/OR RECEIVING SHAFTS AND/OR PITS.



FILL
CLAY
SAND AND SILT
VERY STIFF TO HARD CLAY WITH SAND AND GRAVEL
WEATHERED SHALE
SHALE

30" DIVERSION PIPE PROFILE

SCALE: H:1"=60' V:1"=20'

NOTE: BEDROCK NOT ENCOUNTERED FOR CDM-B-12

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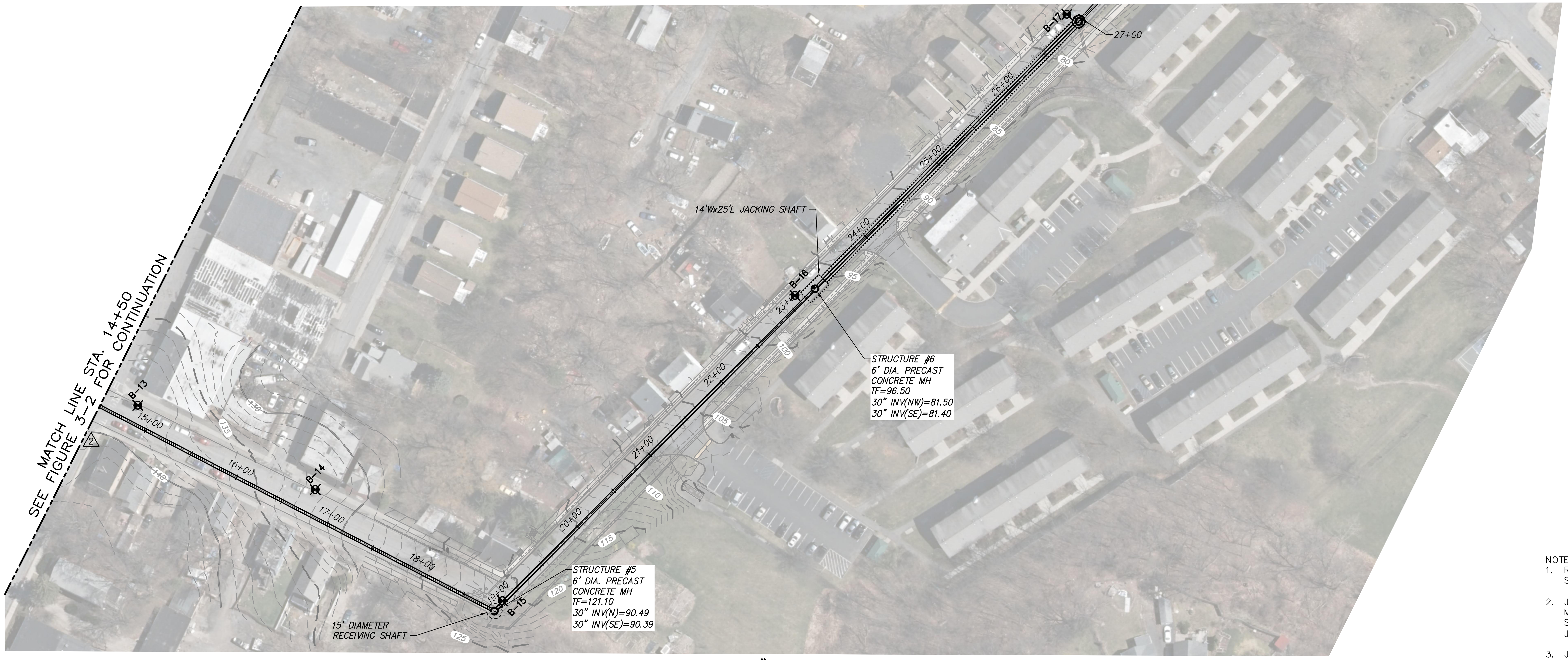
BEAVER CREEK CLEAN RIVER PROJECT

ALBANY, NEW YORK

PROPOSED 30-IN PIPELINE PLAN AND PROFILE

FIGURE 3-2

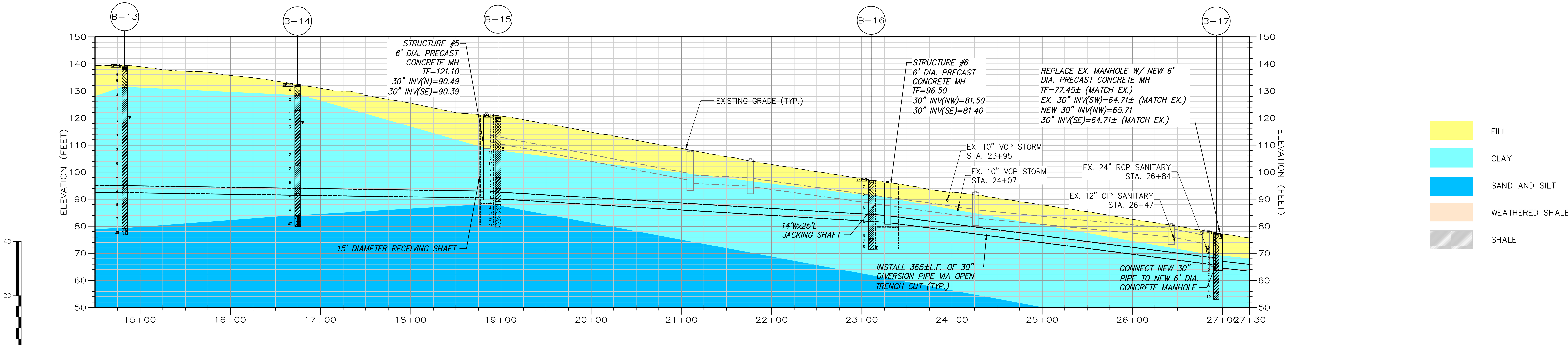


30" DIVERSION PIPE LAYOUT PLAN

SCALE: 1"=60'

NOTE:

1. REFER TO GEOTECHNICAL DATA REPORT FOR THE DETAILS ON SOIL AND ROCK CLASSIFICATION.
2. JACKING AND/OR RECEIVING SHAFT/PIT SIZES SHOWN AS MAXIMUM PERMITTED. CONTRACTOR SHALL BE RESPONSIBLE FOR SIZING, POSITION, ORIENTING, DESIGNING, AND ETC., THE JACKING AND/OR RECEIVING SHAFTS AND/OR PITS.
3. JACKING SHAFT SHOWN AT STRUCTURE 6 MAY BE INTEGRATED AS PART OF THE OPEN-CUT PIPE INSTALLATION BETWEEN STRUCTURE #6 AND LIMIT OF CONTRACT AT APPROXIMATELY STATION 27+00



30" DIVERSION PIPE PROFILE

SCALE: H:1"=60' V:1"=20'

CDM Smith

ALBANY WATER BOARD

BEAVER CREEK CLEAN RIVER PROJECT

ALBANY, NEW YORK

PROPOSED 30-IN PIPELINE PLAN AND PROFILE

FIGURE 3-3

Shaft - Manhole Structure #4

A working shaft centered at Sta. 11+57 will be constructed and used for the tunnel and manhole construction. This shaft will encounter fill, and clay and sand. SPT values in the soil ranged from 5 to 20 bl/ft. Squeezing to raveling soil conditions should be anticipated. Above the water table soil will squeeze or ravel into the excavation. below the water table ductile, plastic yield and flowing conditions may occur due to overstress.

Shaft - Manhole Structure #5

A working shaft centered at Sta. 18+80 will be constructed and used for the tunnel and manhole construction. This shaft will encounter fill, medium stiff clay and dense sand. SPT values in the soil ranged from 4 to 57 bl/ft. Squeezing to raveling soil conditions should be anticipated. Above the water table soil will squeeze or ravel into the excavation. below the water table ductile, plastic yield and flowing conditions may occur due to overstress.

Shaft - Manhole Structure #6

A working shaft centered at Sta. 23+27 will be constructed and used for the tunnel and manhole construction. This shaft will encounter fill, and medium stiff clay. SPT values in the soil ranged from 5 to 8 bl/ft. Squeezing to raveling soil conditions should be anticipated. Above the water table soil will squeeze or ravel into the excavation. below the water table ductile, plastic yield and flowing conditions may occur due to overstress.

3.2 Initial Shaft Support

Shoring is required for the overburden soil and partially weathered rock shaft support. Vertical or near vertical cuts in the exposed shale of the shaft will also be unstable. Contractor is expected to use shotcrete, rock anchors or liner plate for temporary ground support. The minimum support requirements and excavation support design values are shown in the contract drawings. If left unsupported, possible loose fragmented rocks falling as a result of the intensely fractured shale should be anticipated during excavation or other activities in the shaft. When excavating shafts in rock, the joint orientation of the rock should be taken into consideration and additional rock support will be needed to account for joint dipping toward the shaft wall.

It is highly unlikely that a single shaft support system type will be suitable for the anticipated variations in ground conditions. The contractor’s selection of each shaft support type should consider the ground characterization at each individual shaft location discussed in Section 3.1 and the potential groundwater inflows discussed in Section 4.6.5. The shaft support selected shall be coordinated with the proposed dewatering system to provided additional pumping capacity when shoring systems that are not watertight are used.

Manhole structure location 6 is located within public streets and limited access and work area are available. Additional care needs to be taken to prevent damage to roadways, adjacent structures and/or Contractor is required to restore the work area to its original state prior to demobilizing.

3.3 Tunnel Reaches

For the purposes of establishing baselines, the 72-inch and 30-inch tunnel alignments have both been divided into 3 reaches. Reach 3 of the 72-inch tunnel and Reach 2 of the 30-inch tunnel excavation will encounter mixed face tunneling conditions consisting of intensely fractured shale that grades into weathered rock and then clay. Based on the RMR and the Rock Quality Rating or the Q-system, the anticipated rock mass behavior during tunnel excavation is expected to be poor to very poor for shale and the weathered shale. Soil conditions will be firm to slow raveling in accordance with the Tunnelman's Ground Classification system. The anticipated soil strata are shown on Figure 3-1 for the 72-inch tunnel and Figures 3-2 and 3-3 for the 30-inch tunnel. The anticipated stationing for each of the tunnel reaches are shown in **Tables 3-3** and **3-4**.

3.4 Open Cut Segment – Sta. 24+57 to Sta. 27+00

An open cut excavation will begin at Sta. 24+57 and end at Sta. 27+00. This excavation will encounter fill, and very soft to medium stiff clay. SPT values in the soil ranged from weight of hammer to 8 bl/ft. Unstable excavation walls and unsuitable subgrade conditions should be anticipated. Above the water table soil will squeeze or ravel into the excavation, below the water table ductile, plastic yield and flowing conditions may occur due to overstress. The use of additional bedding stone and geotextile should be anticipated to provide a suitable subgrade. For baseline purposes the Contractor should assume 75 percent of the opencut open cut alignment will require 2 feet of subgrade stabilization.

3.5 Tunnel Support Systems

The Contractor is responsible for the installation of all initial support systems as specified and shown on the Drawings to provide for the safety of the excavation and to achieve and maintain stable ground conditions until the carrier pipe is installed. For the purpose of design, the engineer assumed the 30-inch tunnel will be excavated by MTBM and supported by either a casing pipe (two-pass system) or the carrier pipe (one-pass system). The Contractor is required to submit a work plan detailing means and methods that demonstrate adherence to the design intent described here.

It is assumed that the 72-inch tunnel will be excavated by roadheader. The anticipated type of initial support to be installed for the 72-inch tunnel is based on the RMR rating of the rock. This rating has taken into account the orientation of the tunnel heading relative to the rock structure and adjusted accordingly. The RMR system accounts for the span opening of the excavation. The cross-sectional area of the excavated tunnel used for this evaluation and baseline is based on the dimensions shown on the contract drawings and the anticipated excavation method. If the contractor selects a larger cross-sectional excavation to accommodate means and methods an adjustment to the RMR value will be made accordingly so that additional support requirements do not result in additional cost to the Owner. The support type specified is based on the range of RMR values presented in **Table 3-5**.

Table 3-3 72-inch Tunnel Reaches

Tunnel Reach	Reach Station Range (ft)	Face Conditions
1	2+30 to 5+00	Poor to Very Poor-Quality Shale. Fracture spacings of less than 0.3 feet are anticipated. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block.
2	0+75 to 2+30	Poor to Very Poor-Quality Weathered Rock. Fracture spacings of less than 0.3 feet are anticipated. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block.
3	0+00 to 0+75	Mixed Face of Weather Rock and medium stiff Clay. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block.

Table 3-4 30-inch Tunnel Reaches

Tunnel Reach	Reach Station Range (ft)	Face Conditions
1	0+00 to 6+50	Full face of Poor to Very Poor-Quality Weathered Shale and Shale. Fracture spacings of less than 0.3 feet are anticipated. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block.
2	6+50 to 11+50	Mixed Face of Slow to Fast Raveling Sand and Poor to Very Poor-Quality Weathered Rock. Fracture spacings of less than 0.3 feet are anticipated. Poorly interlocked, heavily broken rock mass with mixture of angular and rounded block. Within clayey soil squeezing to raveling soil conditions should be anticipated. Soil will squeeze or ravel into the excavation. Below the groundwater table ductile, plastic yield and flowing conditions may also occur due to overstress. Boulders are anticipated.
4	11+50 to 24+57	Full Face of Squeezing Clay. Squeezing to raveling soil conditions should be anticipated. Soil will squeeze or ravel into the excavation. Below the groundwater table ductile, plastic yield and flowing conditions may also occur due to overstress. Sticky soils are anticipated.

Table 3-5 72-inch Tunnel Support Type

Support Type	Support Description	RMR Range	Baseline Length of Initial Support by Type
1	4-in shotcrete with 2x2 welded wire fabric; Spot bolting as needed	85 to 100	50 ft
2	Pattern of 4 rock bolts, 6.5 ft length at 5 linear feet on center with 4-inch shotcrete and 2x2 welded wire fabric	65 to 85	179 ft
3	Ground improved zone as specified on Contract Drawings or as needed, with 4-in shotcrete with 2x2 welded wire fabric	less than 65	300 ft

3.6 Rock Baselines

The range of rock property parameter values and the baseline properties of the rock are presented in **Table 3-6**. Baseline Rock Properties represent the anticipated condition of the rock prior to construction and does not account for any alteration of the rock conditions caused during construction. **Figures 3-4 through 3-7** are histograms showing frequency of tests within the overall range of the data for this project and of all the data used for UCS tests values, tensile strength, abrasivity and Point Load test.

Table 3-6 – Baseline Rock Values

Baseline Parameter		Strata Unit	
		Weathered Shale	Shale
Unit Weight (pcf)		140	160
Engineering Properties	Uniaxial Compressive Strength (ksi)	0.5-2	0.5 – 2
	Tensile Strength (psi)	100-300	100-300
	Poisson's Ratio	0.25	0.09
	Abrasiveness (Cherchar Abrasion Index)	1.0	1.0
	Slake Durability	80	97

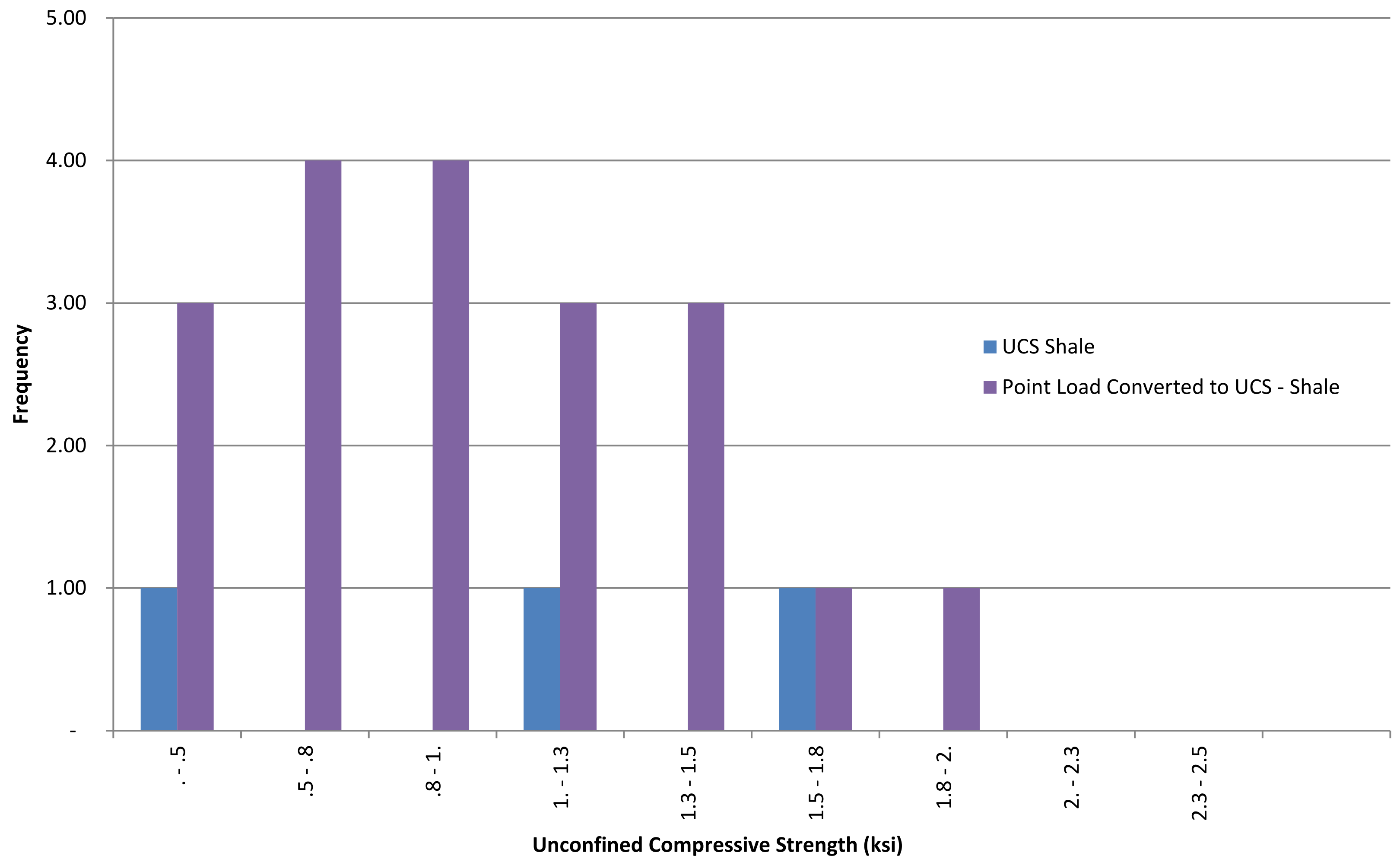
3.7 Additional Baselines

3.7.1 Stickiness/Clogging

The stickiness potential of the soil is presented based on the natural state of the soil without any conditioners. Plots illustrating the stickiness limits of the soils within the tunnel alignment are presented in **Figure 3-8**. For baseline purposes the excavation of the soils within the tunnel alignments is expected to encounter medium to high stickiness soils. Contractor shall be prepared to remove this material from the working chamber of the MTBM and muck handling system or cutter head of the roadheader. For baseline purposes the contractor shall assume that cleaning the cutters on a roadheader or the buckets on the excavators will be required daily during excavation of Reach 3 of the 72-inch tunnel and the open cut segment respectively. Removal of material from the cutting chamber of a MTBM and muck handling systems will be expected up to seven times during completion of the 30-inch tunnel segment.

3.7.2 Boulders and Obstructions

At the tunnel crossings boulders less than 36 inches measured along the longest axis and cobbles (>3 inches and <12 inches in size) will be encountered. The contractor shall use tunneling equipment capable of crushing, cutting, or removing boulders and rock in a mixed face condition. For bidding purposes boulders are considered incidental and a reduced excavation rate shall be included in the contractor's bid for the 30-inch tunnel in tunnel Reach 2 and for removal of the boulders along the open cut alignment. Contractor should anticipate boulders to occur in either



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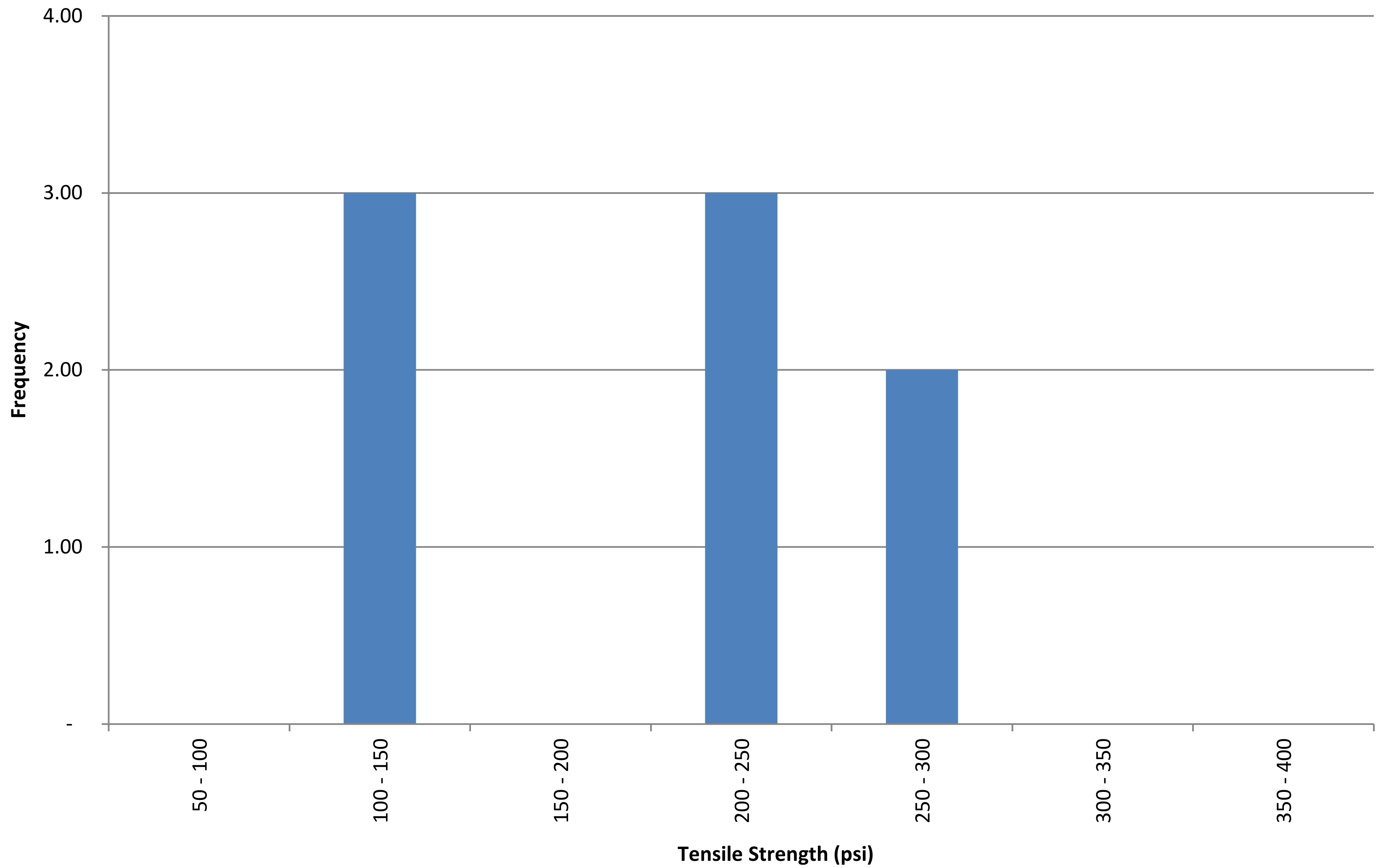
Histogram of Unconfined Compressive Strength Test

Figure 3-4



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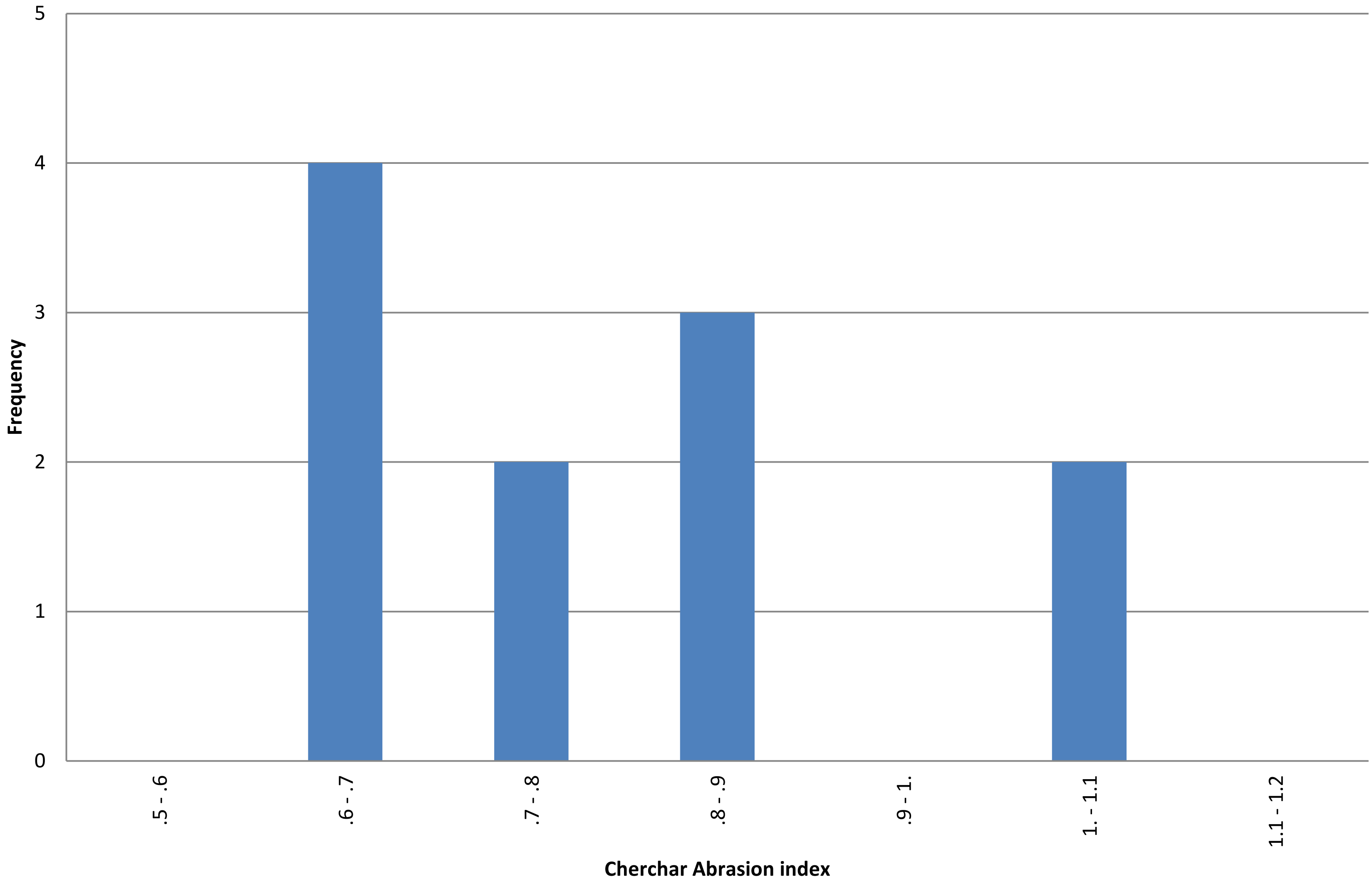
Histogram of Indirect Tensile Strength Test
Figure 3-5



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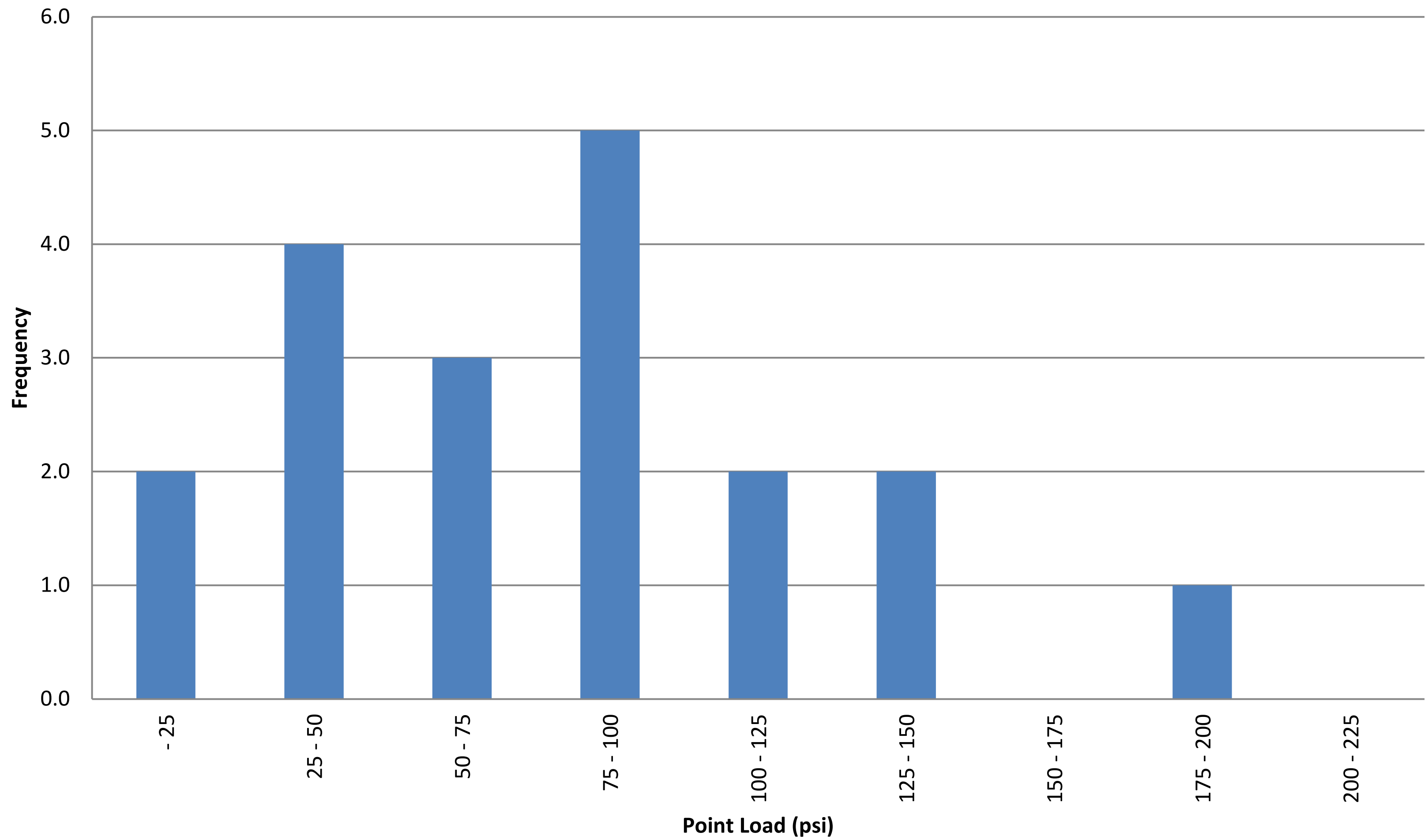
Albany, New York

Histogram of Cherchar Abrasion Test

Figure 3-6



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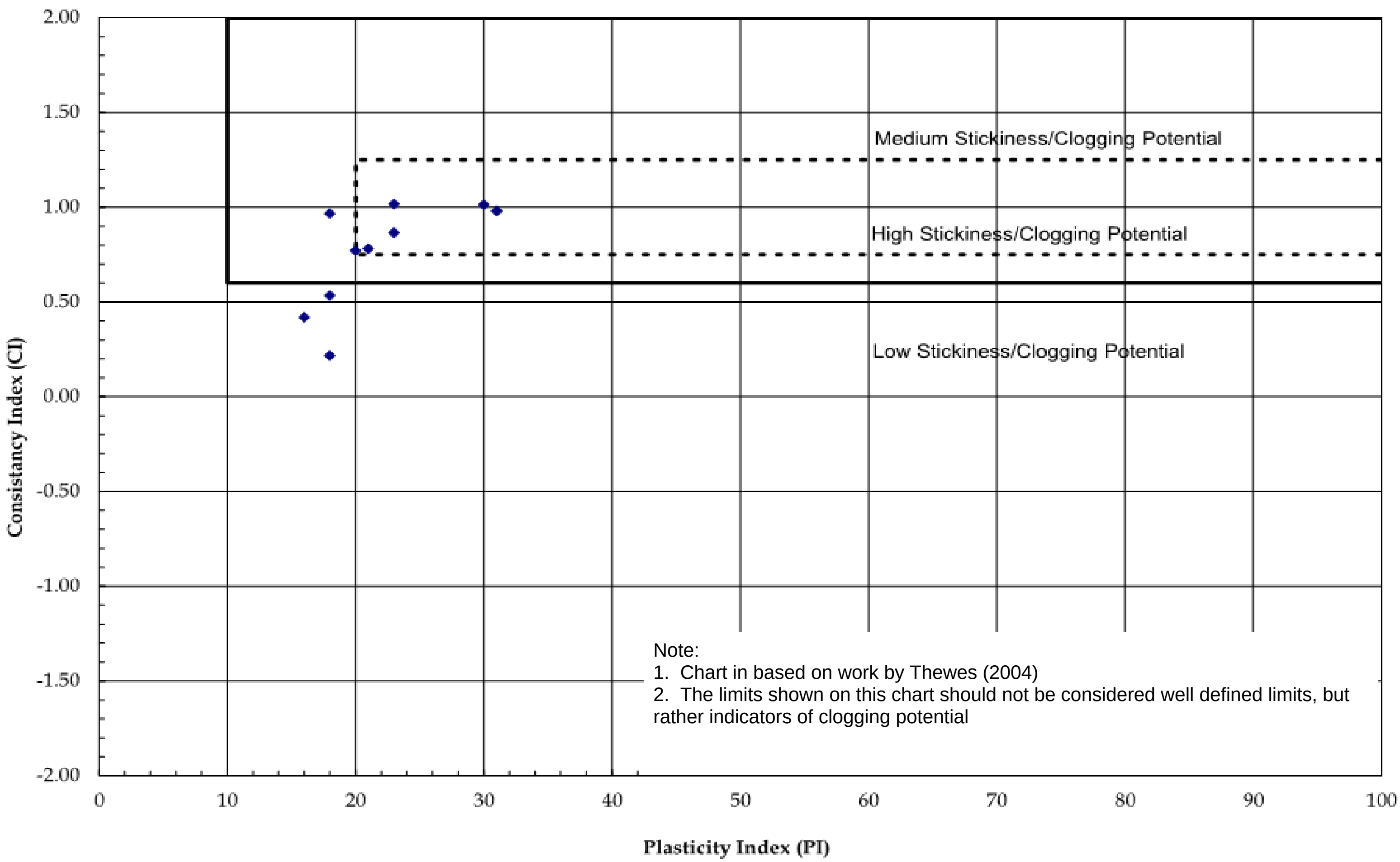
Histogram of Point Load Test

Figure 3-7



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Albany, New York

Stickiness/Clogging Potential
Figure 3-8

isolated locations or in nested zones within the project alignment. Cobbles are considered incidental to the work, and equipment should be capable or excavating them regardless of quantity. The origin of the cobbles and boulders are expected to be consistent with local bedrock. The 30-inch tunnel baseline shall also include, four boulders not consistent with the local bedrock and consistent with granite or other high strength rocks shall also be anticipated.

3.7.3 Excavation of Mixed-Face Conditions

Changes in the face conditions from clay to a granular condition and/or rock are expected to occur along portions of the 30-inch tunnel within a tunnel length of less than 10 feet. In addition, lenses of granular material are expected within clay strata and the tunnel face. Alignment and grade will need to be closely controlled when the tunnel face transitions between the clay strata and more granular strata such as sand and/or harder rock zones. Continuous monitoring and adjustments of alignment, grade and thrust are necessary when tunneling through mixed-face conditions to achieve the alignment and grade tolerances required in the specifications. Changes in the behavior of the excavated materials will also occur as the proportion and orientation of the different strata units exposed in the face change. The selected tunneling equipment and personnel shall monitor and adjust to these anticipated changes in the face conditions in a timely manner to maintain line and grade.

3.7.4 Soil Abrasion

The contractor will encounter highly abrasive dense gravel and sands within the face of the 30-inch tunnel Reach 2. Low abrasive soils are anticipated in Reach 3 of both the 30-inch and 72-inch tunnels. Tunnel Reach 1 and 2 for both, the 30-inch and the 72-inch pipeline, tunnel will be excavated in rock and contractors should refer to the Section 3.5 for rock abrasiveness baselines.

3.7.5 Groundwater Inflow

The control of groundwater entering the shaft and the tunnels both along the excavated tunnel alignment and at the tunnel face is the responsibility of the Contractor. The Contractor's design and implementation of a dewatering system for construction of the tunnel and shafts needs to be capable of adequately controlling both the steady-state and peak inflow values presented in the following section.

Baseline inflow quantities for each tunnel and the shaft and the open cut segment are presented in **Tables 3-7, 3-8 and 3-9**. These values are based on evaluation of the rock quality in borings B-1, B-2, and B-3. Inflow within the shale is expected to be to be at relatively low rates with the exception of significantly higher inflow rates in locations were joints and fractures are encountered below the water table. In the partially weathered rock there are anticipated to be several zones of intense joint fractures where high ground water inflow should be expected. This anticipated rock condition has been taken into account in establishing inflow baseline values in the tables below.

Table 3-7 72-inch Tunnel Groundwater Inflow Quantities

Location	Steady State Inflow	Peak Inflows
Shaft	< 10 gpm	15 gpm for 8 hours
Reach 1	< 10 gpm	15 gpm for 8 hours
Reach 2	< 20 gpm	30 gpm for 8 hours
Reach 3	< 20 gpm	30 gpm for 8 hours

Table 3-8 30-inch Tunnel Groundwater Inflow Quantities

Location	Steady State Inflow	Peak Inflows
Structures 1,4,5,6,7	< 30 gpm	45 gpm for 8 hours
Structures 2,3	< 250 gpm	375 gpm for 8 hours
Reach 1	< 10 gpm	15 gpm for 8 hours
Reach 2	< 120 gpm	180 gpm for 8 hours
Reach 3	< 120 gpm	180 gpm for 8 hours
Reach 4	< 10 gpm	15 gpm for 8 hours

Table 3-9 Open Cut Reach Groundwater Inflow Quantities

Location	Steady State Inflow	Peak Inflows
Station 24+57 to 26+90	< 30 gpm per 100 feet of excavation	45 gpm for 8 hours

3.7.6 Spoil Handling and Disposal

Proper disposal of excavated materials from tunnel and shaft excavations (muck or spoil) is the Contractor's responsibility, in accordance with all applicable State and Federal regulations and permits. For estimating purposes, the Contractor should anticipate that the excavated material is not contaminated.

3.7.7 Noxious or Explosive Gases

Evidence of gas was not identified during the subsurface investigation and no evidence of hazardous gases was found within the borings. For baseline purposes, the operation in the tunnel is classified as non-gassy. However, personnel entering the tunnel should be equipped with appropriate gas detection and monitoring equipment to assure safe working conditions and efficient ventilation through the tunnel and into the reachable areas of the tunneling machine at the heading. The tunnel boring equipment requirements are provided in the Contract Specifications.

3.7.8 Bulkhead

The 72-inch tunnel will require two bulkheads: One at station 0+00 (approx.); another at Sta. 5+29.85 (approx.). Bulkhead represents stabilizing the tunnel excavation, as well as excavation face for follow-on contract to construct final connections. The equipment selected for the tunnel excavation shall be capable of backing out of the tunnel to allow for the bulkhead installation. Contractor will be responsible for final design of the bulkhead. The Contractor is advised that at approximately Sta. 0+00, there is an existing functional brick sewer. The Contractor will protect the brick sewer adjacent to the planned bulkhead location against damage related to any and all construction activities performed for constructing the tunnel and installing the carrier pipe/final liner.

Section 4

Construction Considerations

4.1 General

This section provides a discussion of construction considerations for this project that could be useful to the selected contractor in planning and executing the work. Design considerations for items that will be selected and/or designed by the Contractor or the Contractor's Engineer are also discussed. This section does not change or modify the baseline statement and conditions contained in Section 3 and will not be the basis for any claims for differing site conditions. The selection of the Contractor's construction methods and equipment for each tunnel segment shaft location and the open cut segment should:

- Be suitable for the geologic and hydrogeologic conditions,
- Be capable of achieving reasonable advancement rates,
- Account for the impact available space at the shaft and tunnel segment and provide for necessary safe clearance and other safety precautions,
- Protect adjacent roadways, structures, and utilities,
- Control surface settlement to within specified criteria,
- Control groundwater inflows, and
- Install an initial support system that provides adequate support for the ground.
- Be capable of removal through the excavated 72-inch tunnel prior to installing the bulkhead and carrier pipe.

4.2 Shaft Sites

For all shafts the Contractor's excavation support design must meet required minimum excavation diameter and design requirements as shown on the contract drawings. Where needed, additional excavation can be performed to accommodate the contractors means and methods at no additional cost. However, the limits of all excavations must be maintained within public right-of-way and any indicated easements shown on the contract drawings.

In preparing the design the Engineer has assumed the Contractor will design and install shaft excavation support systems at the shaft locations shown on the Drawings to provide for the safety of the excavation, to achieve and maintain stable ground conditions, and to help limit and manage groundwater inflows until the shaft is backfilled. Additionally, it has been assumed that the Contractor's design of the initial support systems for the excavations shall be compatible with the final lining installations and that internal bracing, ring beams, tie-back anchors, rock bolts, etc., and will not interfere with installation of the carrier pipe, nor construction of the final shaft structure.

The Contractor is advised that some or all of the shafts may require utility relocation and/or in-place utility support.

4.3 Excavation Sequence

4.3.1 72-inch Tunnel Segment

In preparing the design the Engineer has assumed that the contractor's excavation will start at the shaft shown on the contract drawings at Sta. 5+08 and proceed toward Sta. 0+00. The working shaft location will be used by the Contractor for primary tunneling activity and staging area. This working shaft shall be used for construction of the tunnel, for all tunnel access, or for installation of any required ground improvements. Construction of additional shafts to facilitate the contracts means and methods will not be allowed.

4.3.2 30-inch Tunnel Segment

We have assumed that the Contractor's excavation will start at the shaft at Sta. 22+80 and proceed toward Sta. 0+00. However, the sequence of excavation for the 30-inch tunnel segment should be based on the contractors proposed means and methods. The contractor will have the flexibility to select the direction of tunneling and the primary working site location for each tunnel run of the 30-inch tunnel.

4.3.3 Open Cut Segment

Third avenue will be closed to traffic during excavation of the open cut segment. During design it was assumed that the Contractor's excavation will start excavation at Sta. 27+00 and proceed upgrade to allow for groundwater to flow away from the active excavation. However, the sequence of excavation for the open segment should be based on the contractors proposed means and methods. The contractor will have the flexibility to select the direction of excavation and the schedule for laying of the pipe.

It is also anticipated that the contractor will support the trench excavation using trench boxes. Due to the presence of soft soils at or near the pipe invert, additional measures such as driven steel sheets or over excavation and replacement of any soft or heaving subgrade soils with additional bedding material and filter fabrics may also be required to stabilize the excavation bottom. Careful backfilling and compaction of the trench after pipe installation is required to reduce surface settlement of the roadway after construction is completed.

An existing sanitary sewer alignment parallels the open cut alignment. Monitoring requirements of the existing sewer and allowable deformations for the excavation support system are included in contract specifications. Several utilities also cross above the open cut excavation and will require either temporary relocation or to be supported during installation of the new 30-inch pipe. Overhead utility lines are also present along the street and the Contractor should consider overhead clearances when developing the open cut work plan and when selecting equipment.

4.4 Tunnel Excavation

The presence of intensely fractured shale, weathered rock and mixed face conditions are baselined in this GBR. The soil and rock conditions will require careful selection of the tunnel excavation support by the Contractor. The method selection by the contractor will impact excavation rates. Contractors shall review and consider the anticipated ground behavior and all geotechnical data provided prior to tunneling equipment selection.

4.4.1 Selection of Excavation Method for 30-inch Tunnel

The contractor is required to select, design, and utilize a MTBM system capable of excavating the ground conditions stated in Section 3. The Contractors selection of a tunneling equipment and methods also should consider the effects of excavating a mixed face condition and consider soil stickiness as discussed below. The installed pipeline must meet the required 30-inch inside diameter, but the Contractor has the flexibility to mitigate the risk by changing cutters at shaft locations and/or increase the outside excavation as needed to accommodate their means and methods including the installation of a larger diameter casing pipe.

4.4.1.1 Excavation of Mixed-Face Conditions

Alignment and grade control are of particular concern when the tunnels face transitions between the shale and clay strata. Therefore, equipment selection should allow for continuous monitoring and adjustments of alignment, grade and thrust are considered necessary when tunneling through mixed-face conditions. Changes in the behavior of the excavated materials will also occur rapidly as the proportion and orientation of the different strata units exposed in the face change. The speed at which the contractor’s equipment can adjust to changes in strata should be considered.

4.4.1.2 Stickiness

Sticky soils have been identified and baselined within both tunnel segments in Section 3. The potential of the soils to clog the forward chamber of a MTBM should be anticipated. Therefore, clumping, balling and sticking will likely occur, and the material will be difficult to remove from within the working chamber and muck handling system. MTBM’s equipped with water jets or use of ground conditioning additives should be considered to mitigate problems related to clay “stickiness”.

4.4.2 Selection of Excavation Method for 72-inch Tunnel

The Contractor is responsible for the selection, design, and use of an excavation system capable of excavating the ground conditions stated in Section 3. The Contractors selection of a tunneling equipment and methods should anticipate unstable ground if left unsupported and subject groundwater inflows for more than 8 hours. Ground behavior expected to be encountered during open face excavation has been defined in Section 3.

4.4.3 Tunnel Support

As required the tunnel segments will be excavated and meet the minimum support requirements, as shown on the Drawings. The Contactor shall be responsible for selecting the final type/length/ thickness of the initial support lining considering the available space in the working shafts, the anticipated ground conditions to be encountered along the tunnel alignment, and in accordance with the requirements of the Specifications. The Contractor is required to ensure the compatibility of the initial lining used with the selected tunnel excavation methods. For the purposes of design, permitting, and environmental assessment, the excavated diameter meets the required minimum neat line (A-line) shown on the contract drawings so that the final liner can be constructed. Selection of the excavated diameter greater than the minimum required is at Contractor's option. After the tunnel excavation has been completed, the primary liner will be installed, per project specifications and drawings. During construction it is assumed that the final tunnel lining will be installed so as to control groundwater inflow into the finished tunnel during grouting of the lining. Any changes to the tunnel support system proposed by the Contractor must limit groundwater inflow into the finished tunnel as per the contract specifications.

For the 30-inch tunnel segment, the contractor may select either direct jacking the carrier pipe or using a casing pipe for ground support.

The 72-inch tunnel will require Type 3 support or ground stabilization ahead of the excavation for safe excavation of the tunnels as shown on the Contract Drawings. This ground support type may include the installation of spiles, steel pipe arches, or grouting ahead of the face. It should be noted that the interruption of the excavation process for holiday breaks and/or weekends, allows time dependent stress re-distribution. For this reason, strengthening of the initial support near the face should be considered. To guard against this due to planned and unforeseen events, it is recommended that the contractor provide contingencies of sufficient material and equipment on hand to deal with such conditions by reinforcing initial supports if deformation exceeds project specified limiting values.

4.5 Adjacent Structures Protection

A geotechnical instrumentation and monitoring program are included in the Specification Section 31 09 00 of the Contract Documents to monitor deformations during shaft construction and tunneling activities. The allowable ground movements (settlement/heave/deflection) during tunneling, shaft and open cut excavations are provided in the Contract Documents. The Contractor is responsible for selecting and implementing means and methods to perform the tunnel, shaft and open cutwork as specified in these Contract Documents that protects utilities, roadways, railways, and structures from damage, as well as repairing any damage resulting from the work.

The Geotechnical readings from the instrumentation program will be compared with expected deformations for the excavation support systems submitted by the contractor. This process, together with visual observations, is essential for the decision-making process of the determination of adequate performance of each of the ground support categories.

4.6 Groundwater Inflow

4.6.1 30-inch Tunnel

The excavation support system designed by the Contractor will be designed to use either a watertight casing or carrier pipe. It is anticipated that the contractor will utilize a tunnel seal on both the launching and receiving shafts for the 30-inch tunnel segment to control groundwater inflow into the shaft.

4.6.2 72-inch Tunnel

The tunnel dewatering system is anticipated to work in conjunction with a contractor designed sump and pumping system to control groundwater entering the shafts and the tunnel and there by limit adverse effects of lowering the groundwater along the tunnel alignments and any resulting settlement. It is the Contractor's responsibility to select, design and implement additional methods to control groundwater inflows up to the baseline values, such as probe drilling and permeation grouting, at no additional cost to the owner such that the settlements resulting from changes in the groundwater level are within the limiting values listed within the contract specifications.

4.7 Spoil Handling and Disposal

The systems that remove spoil from the tunnel face and transport it to the surface must be capable of transporting all ground and groundwater described in the GDR and Section 3 of this GBR. Contractor is responsible for carefully and deliberately selecting the required equipment, based on available surface space for processing of tunnel spoils, hauling schedules and limited space available at the shaft and portal sites. Proper transportation and disposal of excavated materials from tunnel and shaft excavations (muck or spoil) is the Contractor's responsibility as defined by the Contract Documents.

Section 5

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